Request by WesternGeco, LLC. for an Incidental Harassment Authorization for the Incidental Take of Marine Mammals in Conjunction with a Proposed Marine 2D Seismic Program Mid- and South Atlantic Outer Continental Shelf, 2016-2017

17 February 2016

Submitted to:

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Citation for this report is as follows:

Courbis, S.S., M.A. Smultea, T.F. Norris, D. Steckler, R.P. Walker, T.M. Yack, and K.J. Dunleavy. 2015. Request by Schlumberger/WesternGeco for an Incidental Harassment Authorization for the Incidental Take of Marine Mammals in Conjunction with a Proposed Marine 2D Seismic Program Mid- and South Atlantic Outer Continental Shelf, 2015. Prepared by Smultea Environmental Sciences and Bio-Waves, Inc. for WesternGeco. Submitted to National Marine Fisheries Service, Silver Spring, MD.

Cover photo: North Atlantic Right Whale (*Eubalaena glacialis*) Credit: Georgia Department of Natural Resources, Permit 15488

Summary

This document serves as an application for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) to allow non-lethal "take" (exposure) by harassment of small numbers of marine mammals incidental to two-dimensional (2D) seismic exploration activities proposed by WesternGeco, LLC. beginning in April 2016 in the Mid- and South Atlantic Outer Continental Shelf (MSA OCS) Area of Interest (AOI) managed by the Bureau of Energy Management (BOEM). Seismic operations are proposed to cover up to approximately 26,641 linear kilometers (km) of trackline with an additional 2,734 km of turns and transits. Of the 2,734 km of turns and transits, 257 km is the run-in/ramp-up involving seismic operations before starting each line, 432 km is the run-out involving seismic operations at the end of each line, 985 km will be transited with a single small mitigation seismic source, and 1,059 km will be transited without seismic activity (See Section 1 for definitions of run-in, run-out, and ramp-up). Most of the 29,375 km distance that includes tracklines, run-out, mitigation seismic source activity, and ramp-up/run-in (28,498 km or 97 percent) would occur within the 200 nautical mile (nm) United States (U.S.) Exclusive Economic Zone (EEZ). Seismic operations are estimated to occur during 208 days over a period of about 1 year starting 1 April 2016 (allowing for inclement weather days, potential equipment maintenance/repair and other contingencies). WesternGeco's proposed seismic survey grid area (survey area) extends from approximately 30 km offshore of the southeast coast of Maryland south to 80 km offshore of St. Augustine, Florida (Figure 1-1, 1-2, 1-3, and 1-4). Survey lines extend northwest to southeast from approximately 300 to 500 kilometers (km) offshore over water depths ranging approximately from 20 to 4,700 meters (m).

Thirty-nine of the 41 species of marine mammals that have been documented to occur within or near WesternGeco's proposed survey area are addressed in detail in this IHA. The remaining 2 species not considered in detail herein are the beluga whale (deemed extralimital to the region) and the West Indian manatee [Florida subspecies]). The manatee is under jurisdiction of the U.S. Fish and Wildlife Service and will not be addressed further in this document. Beluga whales are not known to regularly occur in the MSA OCS (Jefferson et al. 2008; LGL 2014a). However, several extralimital beluga sightings were recorded during aerial surveys as far south as 18 km north of the entrance of the Delaware Bay, New Jersey and New York in 1978, 1979 and 1982 (Reeves and Katona 1980; Cetacean and Turtle Assessment Program [CETAP] 1981, 1982; Jefferson et al. 2008). Three belugas were also seen off the coast of New England and south to New Jersey waters near Shrewsbury River in May 2015. NOAA reports that at least 1 of these belugas is part of the St. Lawrence populations of beluga whales (http://www.greateratlantic.fisheries.noaa.gov/stories/2015/may/22_beluga_whales_visiting_new_york.html). Six of the 39 species addressed in this IHA application are listed as endangered under the U.S. Endangered Species Act (ESA): the North Atlantic right, sei, blue, fin, humpback, and sperm whales. No marine mammal species in the survey area are ESA-listed as threatened (Table 4-1). All 39 species are protected by the U.S. Marine Mammal Protection Act (MMPA) (1972).

Sections in this IHA application are organized to follow the 14 items required to be addressed in a request for an IHA pursuant to Chapter 50 of the Code of Federal Regulations (CFR) § 216.104, "Submission of Requests" as outlined in the Table of Contents. Additional figures and tables are provided in Appendices. The italicized statements after each Section number correspond verbatim to the items required in IHA applications from the National Oceanic and Atmospheric Administration (NOAA) Fisheries, Office of Protected Resources website (http://www.nmfs.noaa.gov/pr/permits/incidental.htm). The 14 sections address the following general topics:

- Proposed activities;
- Marine mammal species occurring in the survey area;
- Potential impacts to these species and their habitats, including estimates of the number of individuals that may be exposed to NMFS' recommended exposure criteria; and
- Proposed measures to mitigate and monitor potential effects.

WesternGeco's proposed IHA measures have been developed to reduce and minimize potential impacts to marine mammals by meeting or exceeding the associated mitigation and monitoring requirements identified in the preferred alternative described in the BOEM final Programmatic Environmental Impact Statement (PEIS) and Record of Decision (ROD) (BOEM 2014a, b). This has included avoiding specific areas protected for North Atlantic right whales during their periods of expected use (Appendix A, Table A 1, Figure A 1). Reported densities of most marine mammals in the WesternGeco survey area are relatively low in the majority of the survey area based on a comprehensive review of available data. Proposed mitigation is described in detail in Section 11 "Mitigation Measures." In general, based on available studies, potential reactions to proposed project seismic sounds are expected to be temporary (e.g., short-term behavioral changes or displacement of individuals within ensonified zones associated with seismic operations) and not of biological significance to marine mammal populations. See Section 7, "Anticipated Impact on Species or Stocks" for more information.

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

µPa	micro Pascal
2D	two-dimensional
3D	three-dimensional
4MP	Marine Mammal Monitoring and Mitigation Plan
AAR	Autonomous Acoustic Recorder(s)
AASM	Airgun Array Source Model
AFAST	Atlantic Fleet Active Sonar Training
AHD	Acoustic Harassment Device(s)
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AUTEC	Atlantic Undersea Test and Evaluation Center
AOI	Area of Interest
BO	Biological Opinion
BOEM	Bureau of Ocean Energy Management
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CHASN	Charleston
CHPT	Cherry Point
Com	communication
CPA	Closest Point of Approach
CPT	Crossed Pair Triangulation
CV	Curriculum Vitae(S)
DL	Delisted
DMA	Dynamic Management Areas
DoN	Department of the Navy
D-tags	multi-sensor dataloggers
DZ	Disturbance Zone
EAR	Ecological Acoustic Recorder
EEZ	Exclusive Economic Zone
EN	Endangered
ESA	Endangered Species Act
EZ	Exclusion Zone
FM	Frequency-Modulated
FR	Federal Register
GAMM	Generalized Additive Mixed Model(s)
G&G	Geological and Geophysical
GoM	Gulf of Mexico
GMI	Geo-Marine, Inc.
HARP	High Frequency Acoustic Recording Package(s)
HESS	High Energy Seismic Survey
ID	identification
IHA	Incidental Harassment Authorization
ION	ION Geophysical
IWC	International Whaling Commission
JASCO	JASCO Applied Sciences
JAX	Jacksonville
K	carrying capacity

L-DEO	Lamont-Doherty Earth Observatory
LFAS	Low Frequency Active Sonar
MAB	Mid-Atlantic Bight
MAR	Mid-Atlantic Ridge
MARU	Marine Autonomous Recording Units
MFAS	Mid Frequency Active Sonar
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MONM	Marine Operations Noise Model
ms	millisecond(s)
MSA OCS	Mid- and South Atlantic Outer Continental Shelf
Mysticetus	Mysticetus Observation Platform™
N	North
NAMMCO	North Atlantic Marine Mammal Commission
NEFSC	Northeast Fisheries Science Center
NGDC	National Geophysical Data Center
NL	Not Listed
nm	nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NVD	Night Vision Devices
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OCS	Outer Continental Shelf
OPAREA	Operating Area
OPR	Office of Protected Resources
OSP	Optimum Sustainable Population
PAM	Passive Acoustic Monitoring
PEIS	Programmatic Environmental Impact Statement
pk-pk	peak to peak
PRF	Pulse Repetition Frequency
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
QA/QC	Quality Assurance / Quality Control
RAID	Redundant Array of Independent Disks
RAM	Range-dependent Acoustic Model
re	relative to
RL	received level(s)
rms	root mean square
ROD	Record of Decision
R/V	Research Vessel
S	Strategic
SAB	South Atlantic Bight
SAR	Stock Assessment Report
SECR	Spatially Explicit Capture Recapture

SEL	Sound Exposure Level(s)
SEFSC	Southeast Fisheries Science Center
SERDP	Strategic Environmental Research and Development Program
SES	Smultea Environmental Sciences
Shell	Shell Gulf of Mexico, Inc.
SL	Source Level(s)
SMA	Seasonal Management Area(s)
SOSUS	Sound Surveillance System
SSV	Sound Source Verification
THAMS	Towed Hydrophone Array Mitigation System
TMA	Target Motion Analysis
TNASS	Canadian Trans-North Atlantic Sighting Survey
TTS	Temporary Threshold Shift
UAGI	University of Alaska Geophysical Institute
UK	United Kingdom
UME	Unusual Mortality Event
UNCW	University of North Carolina, Wilmington
USGS	United States Geological Survey
U.S.	United States
VACAPES	Virginia Capes
W	West
ZOI	Zone Of Influence

1 Operations to be Conducted

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

WesternGeco proposes to conduct approximately 23,641 linear kilometers (km) of 2D marine seismic surveys along pre-determined survey lines in the MSA OCS (Figure 1-1 to Figure 1-4) for the period of the NMFS-approved IHA anticipated to span 1 April 2016 to 31 March 2017. An estimate was made of expected turns and transits between survey lines based on the most likely survey route. Turns and transits were estimated to be approximately a total of 2,734 km, 985 km of which is expected to be transited using a small single mitigation seismic source and 1,059 km of which is expected to be transited in silence (i.e., turn/transit will take > 3 hr so no mitigation seismic source will be operated during turn/transit—See Section 11.6.6 for more details). The remaining 690 km includes 257 km of run-in/ramp-up and 432 km of run-out. Ramp-up is the gradual increase in seismic sound sources to full power, which is done as a mitigation measure to allow animals to move away from the sound source before it is at full volume (see Section 11). Run-in/ramp-up is ~3 km of operating the seismic source up to full power before starting a new line to make sure everything is working properly. Run-out is 5 km (approximately half the distance of the acquisition streamer behind the seismic vessel) at which the seismic source is kept at full power beyond the end of a trackline to make sure all data along the trackline are collected by the streamer. Altogether, this results in a total of 29,375 linear km. Subtracting the 1,059 km of silent transit results in a total 28,316 km of seismic activity, of which 877 (3%) will be outside the U.S. Atlantic EEZ.

The purpose of the proposed seismic program is to gather geophysical data using a 5,085 cubic inch (in^3) seismic source array consisting of three strings of eight acoustic sound sources (each with 1,695 in^3 capacity) with 8 meter (m) spacing between strings and a 10.5 km long hydrophone solid streamer (streamer) towed by the seismic vessel. Streamer depth below the water surface is expected to vary from 10 m at the front end (near vessel) to 40 m at the tail end. As the seismic source array is towed along the survey lines, the streamer receives returning acoustic signals and transfers the data to the on-board processing system which then processes the data. Results of the 2D seismic program will be used to identify and map potential hydrocarbon-bearing formations and the geologic structures that surround them.

WesternGeco's seismic operations will occur along pre-determined track lines at speeds of about 4-5 knots (kt) up to 24 hours (hr) per day as possible (except as potentially needed for turns and transits and shut-down for mitigation for marine mammals) (Figure 1-1). The full 5,085 in^3 sound source will be operated only during seismic acquisition operations and near the start and end of survey lines during 3 km run-ins/ramp-ups and 5 km run-outs. During turns and transits between seismic lines, when the full array is being used immediately prior to and will be used immediately after the turn or transit within a 3 hr period, a single "mitigation" source (105 in^3) is proposed to be operated for mitigation purposes, as described for other NMFS-approved seismic operations in the Atlantic and elsewhere (http://www.nmfs.noaa.gov/pr/permits/incidental/). For turns/transits longer than 3 hr, all seismic sources will be turned off after run-out until ramp-up begins 3 km from the start of the next trackline. Ramp-up to full power also begins 3 km before starting a line when the single mitigation seismic source is operating. For purposes of modeling exposures, the seismic array is assumed to be operating at full power for the 3 km ramp-up/run-in and 5 km run-out. WesternGeco will not use explosive charges.

Seismic lines are arranged in a crosshatch pattern running generally NE to SW and NW to SE, comprising 2 survey grids with differently spaced lines in the southwestern study area (Figure 1-1). The widest-spaced lines (25 km spacing) in the southwestern area represent approximately one-third of the project area. The closest spaced lines (6 km spacing) are in the northern and southeastern study area. The proposed seismic survey would comprise 85 individual seismic lines ranging in length from 121 to 752 km (mean line length 303 km). No seismic lines are located closer than 30 km from shore (Figure 1-1).

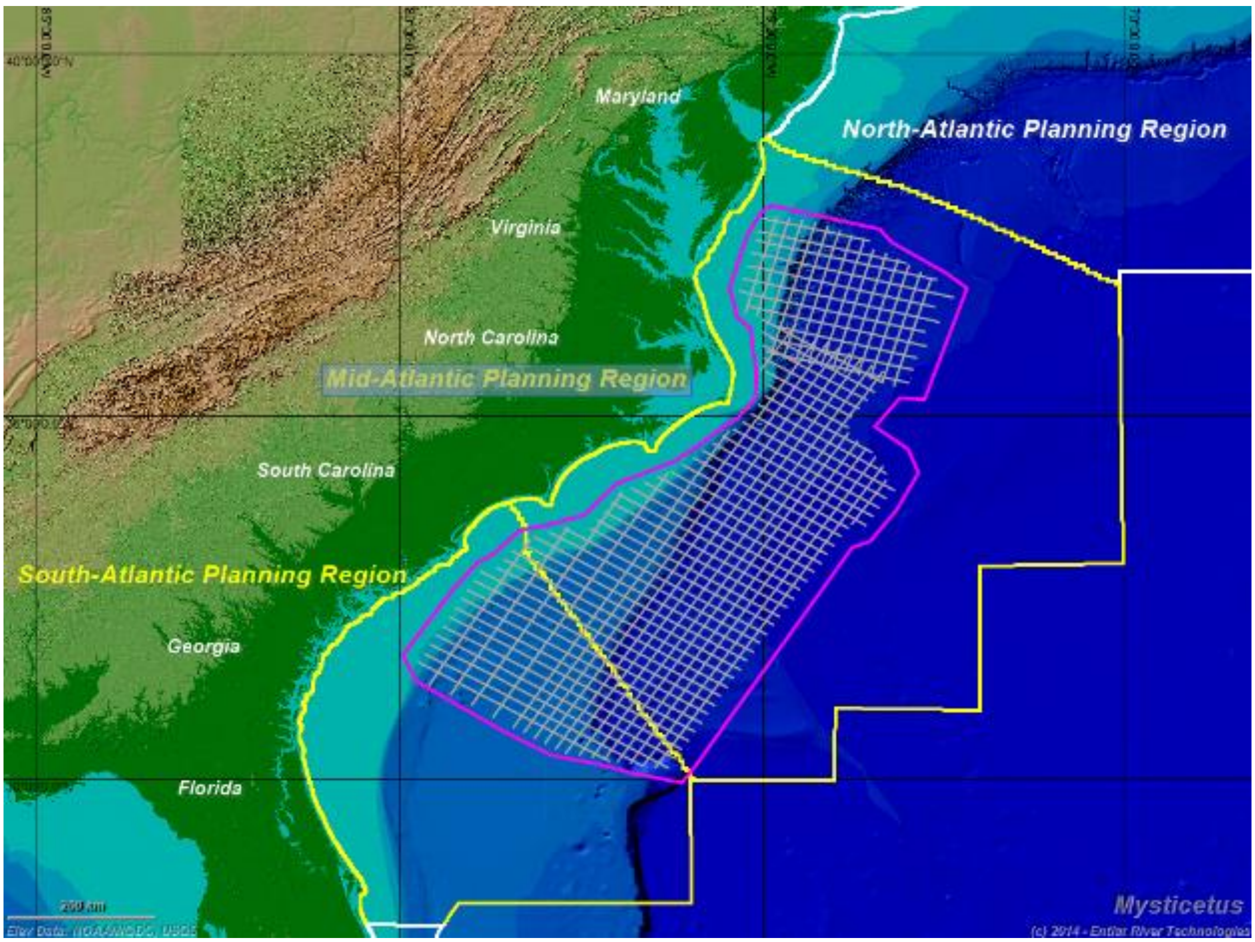

Figure 1-1. Proposed seismic survey lines for WesternGeco's 2D seismic survey area in the Mid- and South Planning Areas in the Atlantic Ocean. Purple line = WesternGeco project area boundary. Yellow line = BOEM Planning Areas.

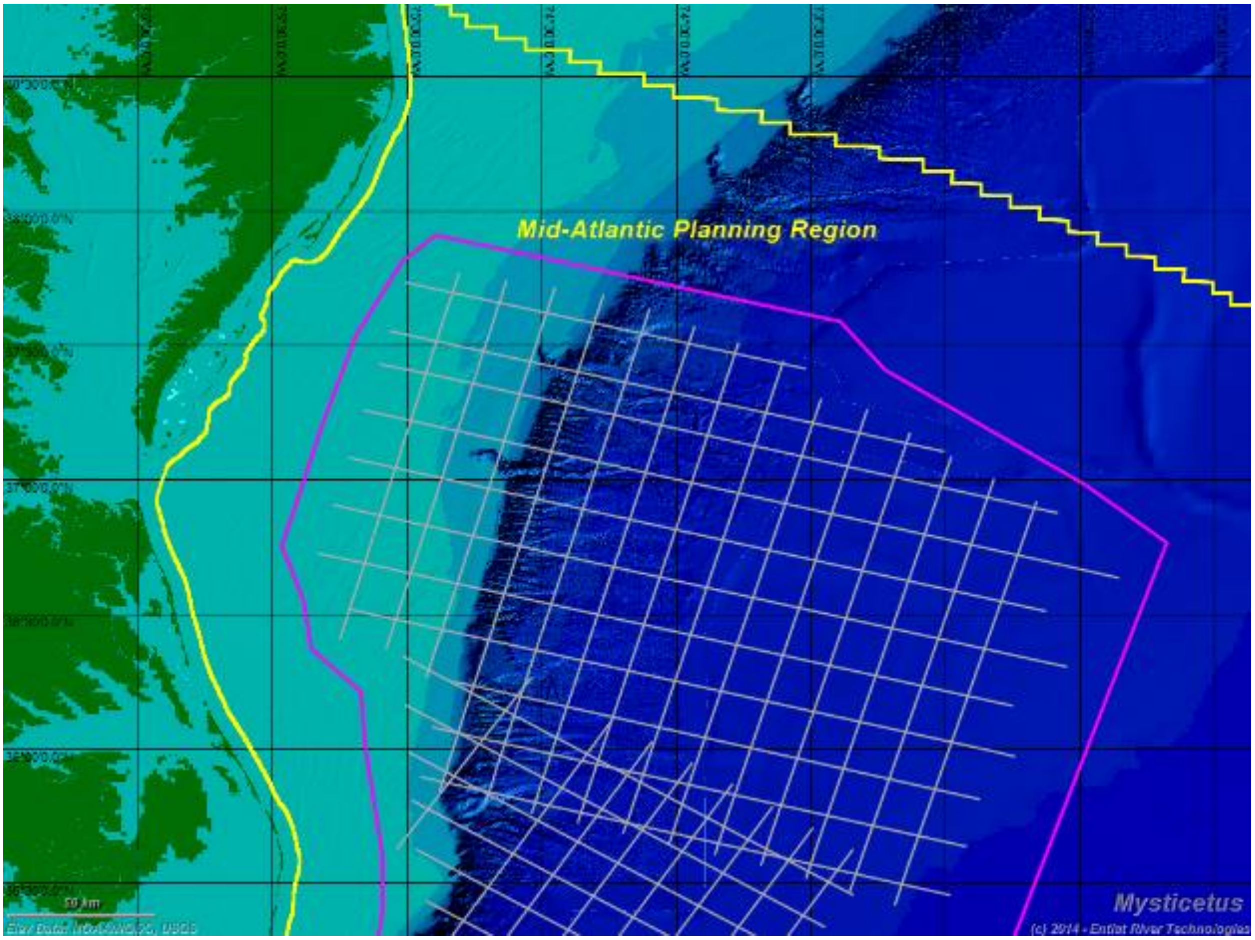

Figure 1-2. Proposed seismic survey lines for WesternGeco's 2D seismic survey area in the northern portion of the Mid- Planning Area in the Atlantic Ocean. Purple line = WesternGeco project area boundary. Yellow line = BOEM Planning Areas.

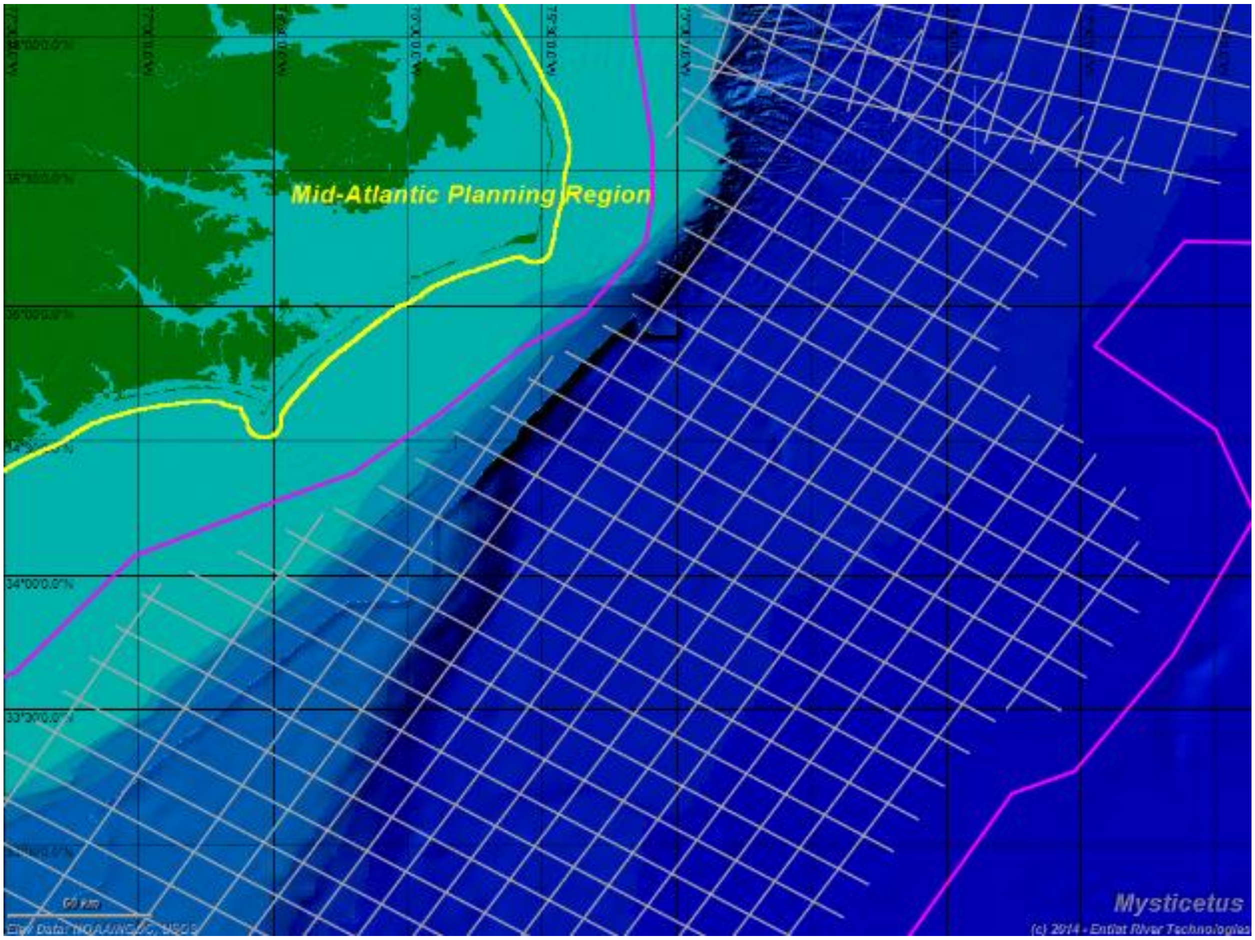

Figure 1-3. Proposed seismic survey lines for WesternGeco's 2D seismic survey area in the middle portion of the Mid- and South Planning Areas in the Atlantic Ocean. Purple line = WesternGeco project area boundary. Yellow line = BOEM Planning Areas.

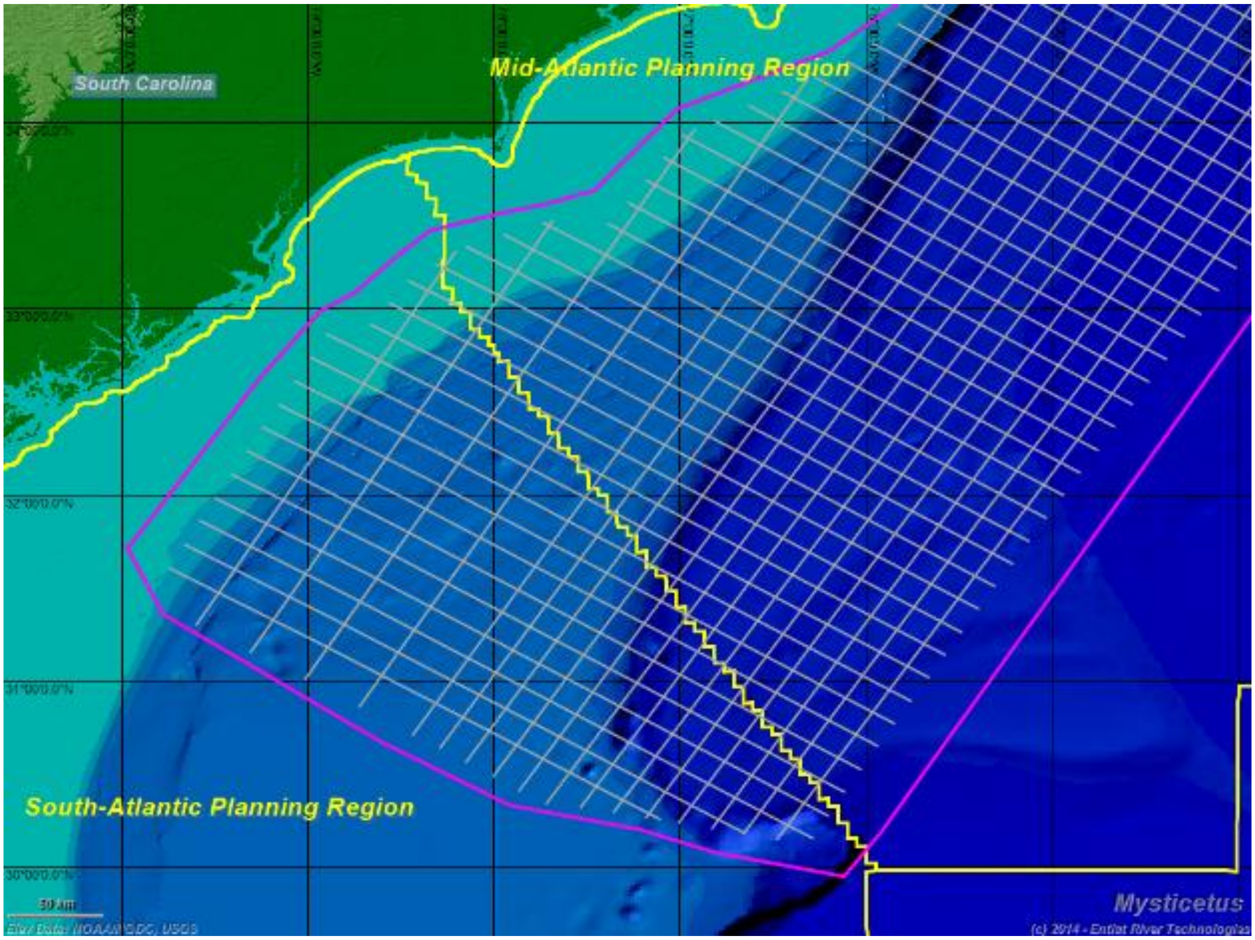

Figure 1-4. Proposed seismic survey lines for WesternGeco's 2D seismic survey area in the southern portion of the Mid- and South Planning Areas in the Atlantic Ocean. Purple line = WesternGeco project area boundary. Yellow line = BOEM Planning Areas.

1.1 Vessels

One seismic vessel will be used during the survey. This vessel will tow a seismic source array and a single 10.5 km long streamer. WesternGeco will also coordinate with other seismic operators that may be in the region to maintain at least the minimum 40 km spacing suggested by the BOEM ROD (BOEM 2014b) between other operating seismic vessels.

The seismic vessel will be accompanied by two smaller chase vessels and a supply vessel. The purpose of the chase vessels is to keep vigil and ensure the safety of the streamer, by warning and keeping nearby vessels away from the streamer vicinity. The two chase vessels may also help to transport field personnel to and from shore, and to tow the seismic vessel in case of emergency due to engine power loss. The vessel that will tow the array is *Western Pride* (registry number 9010125). The two chase vessels will be *Michael Lawrence* (registry number 1243087) and *Amber G* (registry number 31152-05). The supply vessel will be *Melinda B. Adams* (registry number 7644324). Characteristics and photos of these vessels are provided in Appendix B. If for any reason these vessels become unavailable, similar vessels will be used and NMFS will be provided the full vessel specifications. The seismic and chase vessels will be self-contained and crew will live aboard these vessels following scheduled rotations. The support vessel will transit between the survey vessel and port to provide refueling and re-supply. Vessel crew changes will occur every five weeks, with the vessels returning to port or crew will be transferred via the support vessel.

1.2 Seismic Equipment

The seismic vessel will tow a compressed-air seismic source array comprised of 24 Bolt v5085 acoustic sound sources, resulting in a total combined discharge volume of 5,085 in^3. The maximum of 24 operating acoustic sound sources (seismic source) within the full array are arranged in three subarrays totaling 1,695 in3 each. Acoustic sound sources within each of the three subarrays are spaced 8 m apart. The full seismic source array will be towed behind the vessel at a water depth of approximately 12-40 m (+/- 1 m). This seismic array will discharge 43 pulses per statute linear mi (5,280 ft) with a firing distance interval of 37.5 m. The source array will be calibrated and fine-tuned to maximize subsurface illumination and minimize horizontal propagation of noise, as practicable. Additional details regarding seismic acquisition parameters are provided in Appendix B, Table B 1.

The seismic vessel has limited maneuverability while towing the hydrophone streamer and seismic source. To ascertain whether the seismic source array is operating correctly, the full array volume will be enabled with energy slowly increased to full power for 3 km before the start of every line (i.e., "run-in/ramp-up"). In addition, to ensure full-fold (maximum data capacity) data acquisition, the vessel will require a 5 km "run-out" (deconstructing its data capacity before it reaches the next coordinate, typically half of a streamer length) at the end of each line with the seismic array operating at full volume. We anticipate that gravity and magnetic data will also be passively acquired during the survey by measuring gravity and magnetic variations while traversing the lines (no acoustics are emitted with these methods).

The seismic vessel will also tow a single 10.5 km long WesternGeco Nessie-5 hydrophone acquisition streamer behind it at a water depth of approximately 10 m (+/- 1 m) at the front end (near vessel) to 40 m at the tail end; this streamer does not emit any mechanical sounds. The purpose of the streamer is to detect and record pressure fluctuations in the water caused by the reflected sound waves. This streamer allows for a broader band of frequencies to be recorded, resulting in acquisition of finer-detailed geophysical data (i.e., ample sound wave penetration imaging). A marine seismic recorder will be used to record seismic acquisition data (this equipment does not emit any sound).

1.3 Echosounders

The seismic vessel will use industry-standard echosounder/fathometer instruments and they will only be used strictly for navigational safety purposes and not data acquisition. These instruments will obtain information on water depths and potential navigation hazards for vessel crews during routine navigation operations. Navigation echosounders direct a single acoustic signal focused in a narrow beam directly downward to the sea floor. The reflected sound energy is detected by the echosounder that then calculates and displays water depth to the user. Typical source levels (SLs) of these types of navigational echosounders are generally 180–200 decibels (dB) re 1 μPa at 1 meter (1 micro Pascal [μPa] @1m) root mean square (rms) (Richardson et al. 1995). No multi-beam echo-sounders or sub-bottom profilers will be used.

A Simrad™ EA600 echosounder (or equivalent) will operate at high frequencies to assess shallow water depths and at low frequencies to assess deeper water depths. The echosounder emits a downward-facing single beam at frequencies of 38-200 kilohertz (kHz) with an output power of 1-2 kilowatts (kW) rms. Associated pulse durations are 0.5 - 8 (18 kHz) and 0.06 to 1 (200 kHz) milliseconds (ms) long dependent upon water depth, with pulse repetition rate (i.e., the ping rate) related to water depth. The highest pulse repetition frequency (PRF) occurs in shallower water and is approximately 20 pings per minute (min).

1.4 Sound Propagation Modeling

Based on a review of available data on seismic source arrays and associated sound source verification (SSV) modeling, the 2D seismic source array closest in volume to WesternGeco's proposed 5,085 in^3 array was the large (5,400 in^3) seismic source array identified in the BOEM PEIS (BOEM 2014a) (see Appendix B, Table B 1 for comparison between the BOEM modeled sound source and WesternGeco's proposed sound source). Thus, for this IHA application, WesternGeco will henceforth assess potential effects of their proposed operations based on sound propagation modeling associated with this larger (by approximately 315 in^3) 5,400 in^3 seismic array.

Here we simply describe the results of modeling performed for BOEM's PEIS (BOEM 2014a). The SL for the 5,400 in^3 seismic source array (acoustic directional) was predicted using JASCO's Applied Sciences (JASCO) airgun array source model (AASM). To model sound propagation of the seismic array, data collected from 15 oceanographic sites throughout BOEM's AOI were entered into the AASM. The estimated received level (RL) of the 5,400 in^3 array at various distances away was then estimated using the Marine Operations Noise Model (MONM) (with the Range-dependent Acoustic Model (RAM) parabolic-equations model). MONM-RAM estimated RLs based on sound exposure levels (SELs) for low-frequency sources assuming clay or sand bottom composition. For the 15 model sites, 21 model scenarios were used, including modeling in multiple seasons for three sites. Water depths at the 15 example AOI sites varied from 30 to 5,400 m. JASCO applied its MONM to estimate distances from the proposed 5,400 in^3 seismic source array to NMFS' standard 180 and 160 dB re 1 μPa (rms) isopleths. These two isopleths represent current NMFS criteria for assessing the potential level of "take" (i.e., exposure level) for marine mammal mitigation and monitoring requirements (NOAA 2013b, 2014). The resulting BOEM-modeled distances to the 180 dB "exclusion zone" (EZ) and the 160 dB re 1 μPa (rms) "disturbance zone" (DZ) for cetaceans differed with water depth. EZ maximum distances modeled for the 5,400 in^3 array ranged from 799 to 2,109 m for the 180 dB EZ and 5,184 to 15,305 m for the 160 dB DZ (Table 1-1).

Based on data provided in the BOEM PEIS (BOEM 2014a), estimated maximum distance to the 180 dB re 1 μPa (rms) EZ isopleths for the 90 in^3 mitigation source was 76 to 186 m; estimated maximum distance to the 160 dB DZ isopleth was 1,294 to 3,056 m (all dB re 1 μPa [rms]) (Table 1-2). As described above, WesternGeco used the mean of the 95 percent range values of the modeled RL for each of the 21 scenarios as the mitigation distances for the single mitigation source as follows: (1) the implemented 180 dB EZ would be 126 m, and (2) the 160 dB DZ would be 1,486 m (see Section 11.4, Table 1-2, and Appendix C).

For purposes of mitigation, to address the variation in BOEM-modeled distances across the survey area, WesternGeco used the mean of the 95 percent range values of the modeled RL ($R_{95\%}$) for each of the 21 scenarios as the mitigation distances for the full seismic source (including associated ramp up and pre-ramp up periods) as follows: (1) the implemented 180 dB EZ would be 904 m and (2) the 160 dB DZ would be 6,838 m (see Section 11.4 and Table 1-1). Appendix C describes further how these zones were calculated relative to data provided in the BOEM PEIS (BOEM 2014a).

For purposes of exposure estimates, to address BOEM-reported (BOEM 2014b) differences by water depth, we split the 160 dB DZ into 3 exposure radii based on 3 water depth categories. The 15 sites used for modeling RL in the BOEM PEIS ranged in depth from 51 m to 5,390 m (BOEM 2014b). Based on the frequency distribution and means of the latter depth data, WesternGeco applied the following 3 water depth categories: < 880 m depth, 880 to 2,560 m depth, and deeper than 2,560 m depth. The latter delineation of water depth categories was based on a notable gap from 880 m to 2,560 m depth between the BOEM-modeled sites, with no depths modeled in between. Correspondingly, for water depths shallower than 880 m, the mean distance to the 160 dB isopleth was 8,473 m (based on the 11 BOEM-modelled scenario $R_{95\%}$ values for this depth range); for water depths deeper than 2,560 m the mean distance to the 160 dB isopleth was 5,040 m (based on the remaining 10 BOEM-modeled scenarios; Appendix C, Table C 4). We thus applied the following distances from the full seismic source to the 160 dB isopleth for exposure modeling purposes.

1. Where water depth on the survey line was ≤ 880 m, we modeled exposures to the 160 dB (rms) isopleth at a radius of 8,473 m for tracklines/turns/transits for which the array would be at full power (i.e., at all times except when the mitigation seismic source is used during turns/transits < 3 hrs—See Section 11.6.6) at depths of ≤ 880 m.
2. Where water depth on the survey line was ≥ 2,560 m, we modeled exposures to the 160 dB (rms) isopleth at a radius of 5,040 m for tracklines/turns/transits for which the array would be at full power.
3. For depths between 880 m and 2,560 m, there are no specific values modeled in the BOEM PEIS (BOEM 2014a); thus, the mean $R_{95\%}$ for all 21 scenarios (ranging from 51 m to 5,390 m) for the full 5,400 in^3 array was used, corresponding to a 160 dB (rms) isopleth radius of 6,838 m (Appendix C, Table C 3).

The same protocol as described above for the full seismic array was applied for modeling of exposures relative to WesternGeco's proposed single 105 in^3 mitigation seismic source. Again accounting for differences in sound propagation by water depth, we applied the following distances from the single 105 in^3 mitigation source to the 160 dB isopleth for exposure modeling purposes.

1. Where water depth on the survey line was ≤ 880 m, we modeled exposures to the 160 dB (rms) isopleth of the single 90 in^3 mitigation source at a radius of 1,681 m. This consisted of turns/transits during which the mitigation seismic source would be firing (after run-out and before ramp-up for turns/transits < 3 hrs) at depths of ≤ 880 m.

2. Where water depth on the survey line was ≥ 2,560 m, we modeled exposures to the 160 dB (rms) isopleth of the single 90 in^3 mitigation source at a radius of 1,271 m. This consisted of turns/transits during which the mitigation seismic source would be firing (after run-out and before ramp-up for turns/transits < 3 hrs) at depths of ≥ 2,560 m.
3. For depths between 880 m and 2,560 m, there are no specific values modeled in the BOEM PEIS (BOEM 2014a); thus, the mean $R_{95\%}$ for all 21 scenarios (ranging from 51 m to 5,390 m) for the 90 in^3 array was used, corresponding to a 160 dB (rms) isopleth radius of 1,486 m (Appendix C, Table C 3).

Note that the source in the BOEM PEIS is a 90 in^3 source, which is similar in size to the 105 in^3 source proposed by WesternGeco for a "mitigation" source. The 105 in^3 source is the largest single source that would be used as a "mitigation" seismic source. Only 1 individual 105 in^3 source element would be used as the mitigation source; seismic source elements would not be combined to create the 105 in^3.

Table 1-1. Estimated mean distance from the full 5,400 in^3 seismic source array to the National Marine Fisheries Service's (NMFS) recommended 160 and 180 dB re 1μPa (rms) isopleths in the Mid- and South Atlantic Outer Continental Shelf waters based on results of JASCO Applied Sciences sound modeling. These distances will be used for mitigation.

Isopleth (dB re 1 μPa [rms])	Mean modeled distance for the full 5,400 in^3 array (m*)**
180	904
160	6,838

*m = meters
**The distances shown are those proposed to be used for mitigation and monitoring of the 180 dB re 1 μPa (rms) exclusion zone and the 160 dB re 1 μPa (rms) disturbance zone during project seismic operations. Mean distances were obtained by calculating the mean of the 95 percent range values of the modeled RL for the full 5,400 in^3 array for each of JASCO's 21 sound modeling scenarios as presented in the BOEM PEIS (BOEM 2014a). (See Appendix C for more details). Note that WesternGeco proposes to use a 5,085 in^3 full array

Table 1-2. Estimated mean distance from the 90 in^3 single mitigation seismic source to the National Marine Fisheries Service's (NMFS)-recommended 160 and 180 dB re 1 μPa (rms) isopleths in the Mid- and South Atlantic Outer Continental Shelf waters based on results of JASCO Applied Sciences sound modeling. These distances will be used for mitigation.

Isopleth (dB re 1 μPa [rms])	Mean modeled distance for the single 105 in^3 seismic source (m*)**
180	126
160	1,486

*m = meters
**The distances shown are those proposed to be used for mitigation and monitoring of the 180 dB re 1 μPa (rms) exclusion zone and the 160 dB re 1 μPa (rms) disturbance zone during project seismic operations involving the proposed 105 in^3 seismic source. Mean distances were obtained by calculating the mean of the 95 percent range values of the modeled RL for the 90 in^3 seismic source for each of JASCO's 21 sound modeling scenarios as presented in the BOEM PEIS (BOEM 2014a). (See Appendix C for more details).

2 Dates, Duration, and Region of Activity

The date(s) and duration of such activity and the specific geographical region where it will occur.

2.1 Dates and Duration of Activity

This IHA is requested for a one-year period from 1 April 2016 to 31 March 2017. Seismic operations may occur during any hour of the day (including nighttime) during this 365-day period, except for periods of poor weather, equipment repair, shut downs due to mitigation for marine mammals, etc. Specific proposed project start and end dates are listed below, but are contingent on weather, etc.

1. Assuming seismic operations begin on 1 April 2016, the two WesternGeco project vessels plan to depart approximately 7 days prior, near 24 March 2016 and arrive at the survey area approximately 7 days later.
2. Seismic line operations are proposed to begin approximately 7 days after leaving the departure port.
3. Upon completion of data acquisition, all vessels will demobilize to the nearest suitable port; the associated return transit duration would depend upon distance to this port.
4. WesternGeco will adhere to time-area closures for right whales regardless of the period of operations (Figure 2-1).

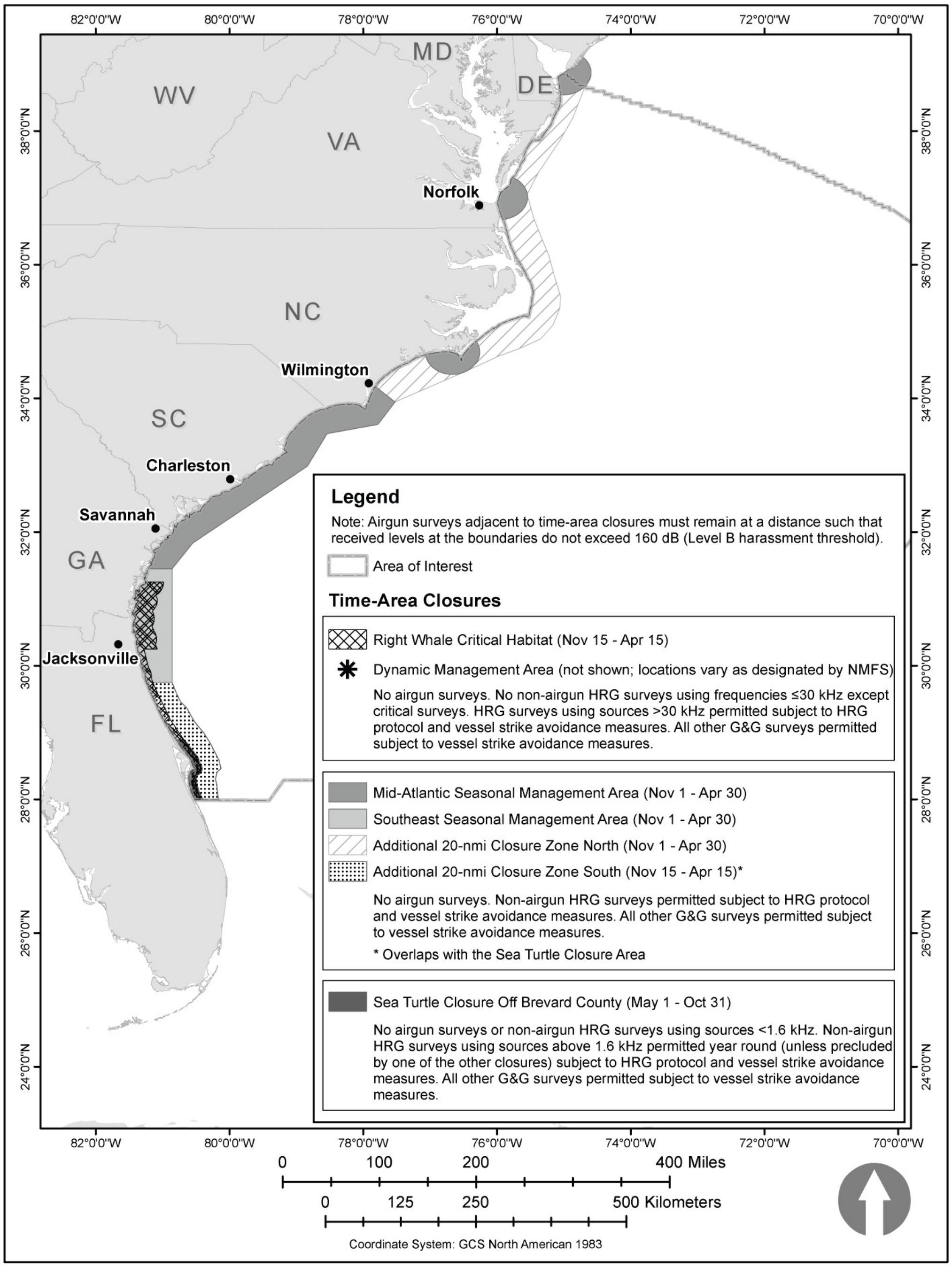

Figure 2-1. Time-Area Closures under Alternative B. Taken from the BOEM PEIS (BOEM 2014a).

2.2 Region of Activity

The seismic operations are proposed to occur within and beyond the U.S. Exclusive Economic Zone (EEZ) (offshore to the extended continental shelf [200 nm limit]) waters of the northwestern Atlantic Ocean between the northern limit of 38°North (N) and the southern limit of 30°N (Figure 2-2).

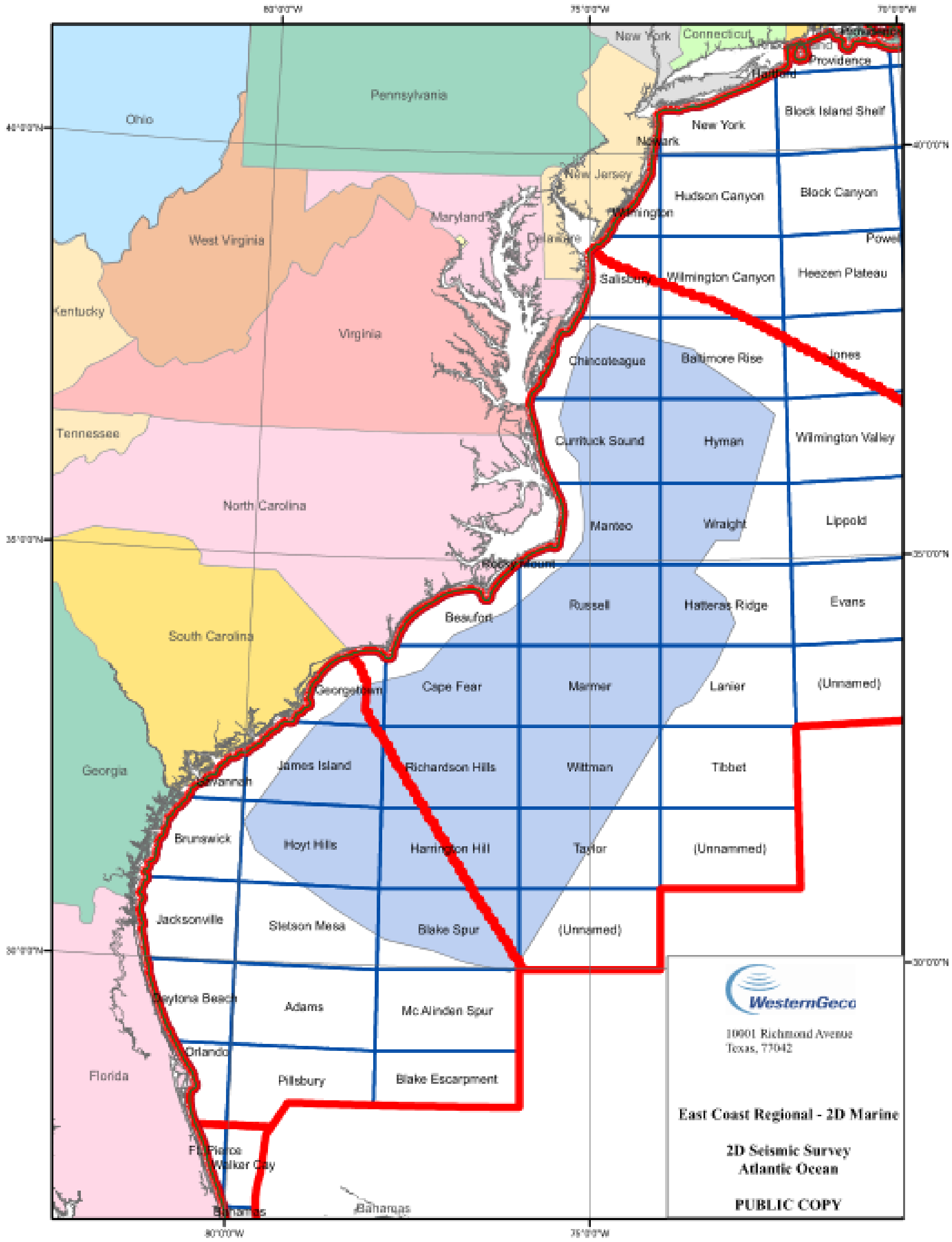

Figure 2-2. WesternGeco's 2D proposed seismic survey area in the Mid- and South Planning Areas in the Atlantic Ocean.

3 Species and Numbers of Marine Mammals in Area of Interest

The species and numbers of marine mammals likely to be found within the activity area.

Identification of the 39 marine mammal species under NMFS jurisdiction that are expected to or may occur regularly or rarely in WesternGeco's proposed survey area was determined based on an up-to-date literature review of the 2013 NMFS Stock Assessment Report available at the time of this application submittal (Waring et al. 2014), as well as other documents (e.g., Department of the Navy [DoN] 2013; Bureau of Ocean Energy Management [BOEM] 2014a). Nineteen of the 39 species addressed in this IHA are considered "regular" (i.e., common) inhabitants at least seasonally and have been documented within the WesternGeco survey area; the remaining 20 species are considered rare (Table 4-1). Some species that are common in the North Atlantic U.S. EEZ are not common in the WesternGeco proposed seismic survey area (see Section 6.0 for more details). The 39 species represent 2 taxonomic orders:

1. The Cetacea (consisting of 8 large whale, 15 small whale, 12 dolphin, and 1 porpoise species)
2. The Carnivora (consisting of 4 "true seals").

Four species of true seal may be found in the survey area. Generally, these species are rare in the AOI, as their ranges are historically further north. However, documented sightings and stranding events have increased in the mid-Atlantic region over the last decade (BOEM 2014a).

Six marine mammal species occurring in the survey area are listed as endangered or threatened under the U.S. Endangered Species Act (ESA) of 1973 (35 Federal Register [FR] 18319; Perry et al. 1999):

- North Atlantic right whale,
- Sei whale,
- Blue whale,
- Fin whale,
- Humpback whale
- Sperm whale

NOAA has recently proposed to revise the ESA listing of humpback whales. Under this revision, there would be 14 Distinct Population Segments (DPSs), and the DPS to which North Atlantic humpback whales would belong (West Indies DPS) would not be listed as endangered or threatened (80 FR 22304).

In summary, 39 marine mammal species known to occur in the MSA OCS, and expected to or potentially occurring in the WesternGeco survey area, are addressed in this IHA based on their reported occurrence of rare to regular. To avoid redundancy, the estimated numbers of individuals of the 39 species that are known to or may be present in the survey area are further discussed in Section 4 below. Species scientific names are provided in Table 4-1.

4 Status, Distribution, and Seasonal Distribution of Affected Species or Stocks of Marine Mammals

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities.

As indicated in Section 3, four of the 39 species regularly occurring (North Atlantic right, humpback, fin, and sperm whales) and 2 of the 39 species rarely or possibly occurring (sei and blue whales) in the WesternGeco survey area are listed as endangered under the ESA (no marine mammal species in the survey area are listed as threatened under the ESA) (Table 4-1). As mentioned above, NOAA has proposed to revise the status of humpback whales such that the West Indies DPS to which North Atlantic humpback whales belong would not be listed (80 FR 22304). All 39 species are protected by the U.S. Marine Mammal Protection Act (MMPA) (1972) and are the species for which potential incidental exposures of small numbers of marine mammals are requested in this IHA.

Species' status, estimated stock abundance, and general and seasonal distribution and occurrence relative to the survey area during the proposed seismic project are discussed in ensuing subsections and in Table 4-1 (in taxonomic order). This information was presented in detail in the BOEM MSA OCS PEIS (2014a). Therefore, the following sections reference this PEIS but focus on additional up-to-date and/or more detailed data specific to the survey area region since the PEIS was published. Note that to minimize repetition of text, information on the abundance of each species is included Table 4-1 and not necessarily in the text of Section 4.0. For further treatment of species abundance see Section 6.4.

Hundreds of studies and/or summary reviews have been undertaken in Atlantic waters addressing marine mammals within or near the WesternGeco survey area region (see Section 15, "Literature Cited"). Some of the more recent surveys conducted in the North Atlantic region are briefly summarized below in descending chronological order. They were reviewed for species occurrence, numbers and distribution with relevant data included in this IHA as applicable (e.g., species and impacts sections). In addition, the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) database was referenced for marine mammal sighting and seasonal occurrence data within the survey area. Additional studies addressing particular species, focusing on recent and/or unpublished data and reports, are referenced under each species section.

Since 2009, the U.S. Navy has been conducting training operations within the MSA OCS off the U.S. Atlantic and Gulf Coasts within 3 operating areas (OPAREA) known as the Atlantic Fleet Active Sonar Training (AFAST) Study Area (DoN 2013):

1. Virginia Capes (VACAPES),
2. Cherry Point (CHPT), and
3. Charleston-Jacksonville (CHASN-JAX) range complexes.

The U.S. Navy, in association with NMFS, has developed a program to monitor the impacts of training operations involving mid-frequency and high-frequency active sonar on federally protected species—specifically marine mammals and sea turtles (DoN 2013). Monitoring studies have been conducted by numerous non-U.S. Navy civilian academic, government, and contractor scientists along with U.S. Navy marine species technical experts (DoN 2013). From 22 January 2009 – 1 August 2012, a total of 20 cetacean species comprising 542 sightings of 2,742 individuals have been sighted in the 3 OPAREAs during various monitoring and other studies; no pinnipeds were sighted. Vessel, aerial, and acoustic monitoring effort was conducted by Duke University, HDR, Inc., University of North Carolina at Wilmington, Smultea Environmental Sciences, LLC., the Centre for Ecological and Environmental Modeling, University of St. Andrews, Cornell University Bioacoustics Research Program, Scripps Institution of Oceanography, and Bio-Waves, Inc.

In April-May 2013, L-DEO, with funding from the U.S. National Science Foundation (NSF), conducted a high-energy, 2D seismic survey on the Mid-Atlantic Ridge (MAR) in the Atlantic Ocean (LGL 2013). The survey occurred approximately 3,700 km east of the WesternGeco survey area, between about 35.5–36.5°N latitude and ~33.5–34.5°West (W) longitude on the MAR in International Waters (approximately 300 km from the Azores) (LGL 2013). Average waters depths were 900–3,000 m (LGL 2013). A total of 119 sightings of 83 individuals of 4 cetacean species and 33 sea turtles were recorded visually and acoustically (Milne et al. 2013). No pinnipeds were seen.

In June–July 2013, L-DEO, with funding from the U.S. NSF, conducted another high-energy, 2D and 3D seismic survey in the northeast Atlantic Ocean Deep Galicia Basin west of Spain (Cameron et al. 2013). The seismic survey area was located between ~41.5–42.5°N and ~11.5–17.5°W with water depths that ranged from ~3500 m to > 5000 m (Cameron et al. 2013). The survey occurred approximately 6,000 km east of the WesternGeco survey area. A total of 4,998 km (3,105 mi) of transect lines were surveyed during 642 hr of observation effort from 1 June to 2 August (Cameron et al. 2013). A total of 1,555 sightings of 439 individuals of 9 cetacean species were recorded (Cameron et al. 2013). No pinnipeds were seen.

In 2009, Rice University collected marine seismic data during a low-energy seismic survey off New England in the Northwest Atlantic Ocean from 12-25 August 2009 (Holst and Robertson 2009). The geographic region where the survey occurred was over the continental shelf south of Martha's Vineyard and Nantucket, Massachusetts. The survey area was located between 40 and 41.3°N and between 69.7 and 70.7°W, within the U.S. EEZ (Holst and Robertson 2009). The survey occurred approximately 300 km north of the WesternGeco survey area. Average waters depths were ~25–200 m, but typically were < 100 m (Holst and Robertson 2009). A total of 1,443 km (896 mi) of seismic operations and about 2,244 of visual observation effort occurred during 14 days. Fourteen cetacean species were identified. No pinnipeds were seen. A total of 14 sightings of 601 marine mammals were seen (Holst and Robertson 2009).

Table 4-1. List of the 39 marine mammal species documented or possibly occurring in the survey area and their status, abundance, distribution, habitats, and seasonal occurrence on the Mid- and South Atlantic Outer Continental Shelf. Species are presented in taxonomic order. N/A = Not Applicable -- data not available. If no values are available for Stock Assessment Report (SAR) or regional estimates, "unknown" is indicated in the table.

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
Cetacean						
North Atlantic Right Whale *Eubalaena glacialis* (Western Atlantic)	EN(S) (designated as depleted)	Unknown[25]	Regular	Appear to prefer bays and coastal waters	Seasonal coastal migrant late fall to spring between more northern summer feeding grounds and winter calving grounds off the U.S southeast coast	Cape Cod Bay/Massachusetts Bay, Great South Channel, and southern coast of Georgia/northern coast of Florida; critical habitat is currently under review
Blue Whale *Balaenoptera musculus* (Western North Atlantic)	EN(S) (designated as depleted)	855[6] / Unknown[26]	Rare	Shelf breaks, sea mounts	Occasional, seasonal migrant during the spring, occasional feeding	N/A
Fin Whale *Balaenoptera physalus* (Western North Atlantic)	EN(S) (designated as depleted)	26,500[7] / 1,618[27]	Regular north of Cape Hatteras	Shelf breaks, sea mounts, mid-Atlantic ridge mid-ocean	Migration patterns unknown; may not migrate like other baleen whales; most found north of AOI[3]	N/A

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
Sei Whale *Balaenoptera borealis* (Nova Scotia)	EN(S) (designated as depleted)	10,300[8] / 357[9]	Rare	Continental shelf edge regions, occasionally shallow, inshore waters	Spring and summer; occasional, major stock portion centered north of AOI	N/A
Bryde's Whale *Balaenoptera brydei* (no SAR for Western Atlantic)	NL	Unknown	Rare	Oceanic waters	Unknown; considered a secondary range	N/A
Common Minke Whale *Balaenoptera acutorostrata* (Canadian East Coast)	NL	138,000[10] / 20,741[11]	Rare	Continental shelf	Common in summer, largely absent in winter	N/A
Humpback Whale *Megaptera novaeangliae* (Gulf of Maine)	EN(S) (designated as depleted) (Note NOAA has proposed an unlisted DPS for this region)	11,600[12] / 823[13]	Regular	Continental shelf regions, coastal waters	Spring, summer and fall	N/A

Species (*Stock*)	U.S. Federal Status (Stock Status)[1,2]	Regional/SAR Abundance Estimates[3]	Relative Occurrence in Atlantic Ocean[4]	Preferred Habitat in Atlantic Ocean*	Seasonal Occurrence in Western Atlantic Area of Interest (AOI)**	Critical Habitat in the AOI
Sperm Whale *Physeter macrocephalus* (North Atlantic)	EN(S) (designated as depleted)	13,190[14] / 2,288[15]	Regular	Continental shelf and shelf edge	Year-round, distinct seasonal patterns: winter off North Carolina; spring off Delaware, Virginia and throughout central mid-Atlantic bight; summer as far south as New England; fall in Mid-Atlantic Bight	N/A
Pygmy Sperm Whale *Kogia breviceps* (Western North Atlantic)	NL	N/A / 3,785[16]	Regular	Oceanic waters, common along the shelf break	Year-round	N/A
Dwarf Sperm Whale *Kogia sima* (Western North Atlantic)	NL	N/A / 3,785[16]	Regular	Oceanic waters, more pelagic than pygmy sperm whale	Year-round	N/A
Cuvier's Beaked Whale *Ziphius cavirostris* (Western North Atlantic)	NL	N/A / 6,532[5]	Regular	Continental shelf edge in the mid-Atlantic	Late spring and summer	N/A

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
Northern Bottlenose Whale *Hyperoodon ampullatus* (Western North Atlantic)	NL	Unknown	Rare	Deep oceanic waters	Spring and summer	N/A
Blainville's Beaked Whale *Mesoplodon densirostris* (Western North Atlantic)	NL	N/A / 7,092[18]	Regular	Continental shelf edge in the mid-Atlantic	Late spring and summer, correlated with survey efforts	N/A
Sowerby's Beaked Whale *Mesoplodon bidens* (Western North Atlantic)	NL	N/A / 7,092[18]	Regular	Continental shelf edge in the mid-Atlantic	Late spring and summer, correlated with survey efforts	N/A
Gervais' Beaked Whale *Mesoplodon europaeus* (Western North Atlantic)	NL	N/A / 7,092[18]	Regular	Continental shelf edge in the mid-Atlantic	Late spring and summer, correlated with survey efforts	N/A

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
True's Beaked Whale *Mesoplodon mirus* (Western North Atlantic)	NL	N/A / 7,092[18]	Regular	Continental shelf edge in the mid-Atlantic	Late spring and summer, correlated with survey efforts	N/A
Killer Whale *Orcinus orca* (Western North Atlantic)	NL	Unknown	Rare	Offshore	Warm seasons with occurrence unpredictable	N/A
Long-finned Pilot Whale *Globicephala melas* (Western North Atlantic)	NL	780,000[19] / 26,535[5]	Regular	Oceanic waters, continental shelf edge, high relief or submerged banks	Winter and early spring along shelf edge, late spring to late autumn north of AOI at Georges Bank and Gulf of Maine	N/A
Short-finned Pilot Whale *Globicephala macrorhynchus* (Western North Atlantic)	NL	780,000[19] / 21,515[5]	Regular	Oceanic waters, continental shelf edge, high relief or submerged banks	Winter and early spring along shelf edge, late spring to late autumn north of AOI at Georges Bank and Gulf of Maine	N/A
False Killer Whale *Pseudorca crassidens* (Western North Atlantic)	NL(S)	Unknown / 442	Unknown	Oceanic waters	Spring and Summer	N/A

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
Pygmy Killer Whale *Feresa attenuata* (Western North Atlantic)	NL	Unknown	Rare	Offshore	Unknown	N/A
Melon-headed Whale *Peponocephala electra* (Western North Atlantic)	NL	Unknown	Rare	Oceanic waters	Unknown	N/A
Rough-toothed Dolphin *Steno bredanensis* (Western North Atlantic)	NL	N/A / 271[5]	Rare	Deep oceanic waters, can also be seen in shallow waters	Unknown but mostly in southeastern U.S.	N/A
White-Beaked Dolphin *Lagenorhynchus albirostris* (Western North Atlantic)	NL	N/A / 2,003[5]	Rare	Offshore, continental slope	Year-round with greatest proportion of population seen in spring, concentrated in western Gulf of Maine and around Cape Cod	N/A

Species (*Stock*)	U.S. Federal Status (Stock Status)[1,2]	Regional/SAR Abundance Estimates[3]	Relative Occurrence in Atlantic Ocean[4]	Preferred Habitat in Atlantic Ocean*	Seasonal Occurrence in Western Atlantic Area of Interest (AOI)**	Critical Habitat in the AOI
Atlantic White-Sided Dolphin *Lagenodelphis acutus* (Western North Atlantic)	NL	10s to 100s of 1000s[20] / 48,819[5]	Rare	Continental shelf waters	Year-round with seasonal distribution changes: Jan-May low densities Georges Bank to NH (few sightings as far south of NC); June-Sept increased abundance Georges Bank to lower Bay of Fundy; Oct-Dec intermediate densities southern Georges Bank to southern Gulf of ME	N/A
Risso's Dolphin *Grampus griseus* (Western North Atlantic)	NL	N/A / 18,250[5]	Regular	Continental shelf edge; slope waters in winter	Year-round; regular during spring, summer and autumn Cape Hatteras to Georges Bank; Mid-Atlantic Bight slope waters in winter	N/A
Bottlenose Dolphin *Tursiops truncatus* (Western North Atlantic Offshore, 1 stock)	NL	N/A/ 77,583[21]	Regular	Outer continental shelf and slope, also documented relatively close to shore near NC, may overlap with coastal in the southeastern U.S	Year-round	N/A

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
Bottlenose Dolphin *Tursiops truncatus* (Coastal, 5 stocks)	NL(S) (designated as depleted)	N/A / 31,212[21]	Regular	Inshore waters ; higher densities within inner shelf areas	Year-round	N/A
Bottlenose Dolphin *Tursiops truncatus* (Estuarine, 11 stocks)	NL(S)	N/A / 1,813 (+ 6 stocks unknown)[21]	Regular	Estuarine and bays	Year-round	N/A
Pantropical Spotted Dolphin *Stenella attenuata* (Western North Atlantic)	NL	N/A / 4,439[5]	Regular	Coastal and oceanic waters, along continental shelf edge and slope	Year-round	N/A
Atlantic Spotted Dolphin *Stenella frontalis* (Western North Atlantic)	NL	N/A / 44,715[5]	Regular	Inshore waters and along continental shelf edge and slope	Year-round	N/A

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
Spinner Dolphin *Stenella longirostris* (Western North Atlantic)	NL	Unknown	Rare	Offshore, deep water	Unknown	N/A
Clymene Dolphin *Stenella clymene* (Western North Atlantic)	NL	N/A / 6,086[22]	Rare	Coastal and oceanic waters, along continental shelf edge and slope	Unknown	N/A
Striped Dolphin *Stenella coeruleoalba* (Western North Atlantic)	NL	N/A / 54,807[5]	Regular	Continental shelf to mid-Atlantic region	Year-round	N/A
Short-beaked Common Dolphin *Delphinus delphis* (Western North Atlantic)	NL	N/A / 173,486[5]	Regular	Continental shelf and slope	Year-round: mid-Jan-May Cape Hatteras to Georges Bank; mid-summer to autumn north to Scotian Shelf from	N/A

Species (*Stock*)	U.S. Federal Status (Stock Status)[1,2]	Regional/SAR Abundance Estimates[3]	Relative Occurrence in Atlantic Ocean[4]	Preferred Habitat in Atlantic Ocean*	Seasonal Occurrence in Western Atlantic Area of Interest (AOI)**	Critical Habitat in the AOI
Fraser's Dolphin *Lagenodelphis hosei* (Western North Atlantic)	NL	Unknown	Rare	Oceanic waters; may occur closer to shore in areas where deep water approaches the coast	Uncommon	N/A
Harbor Porpoise *Phocoena phocoena* (Gulf of Maine/Gulf of Fundy)	NL	~500,000[23] / 79,883[24]	Rare	Shallow waters of the continental shelf, occasionally offshore	Year-round: Jan-Mar Canada to NC; Jul-Sep northern Gulf of ME and southern Bay of Fundy; Oct-Dec and Apr-June NJ to ME	N/A
Pinniped						
Harbor Seal *Phoca vitulina* (Western North Atlantic)	NL	N/A / 75,834[5]	Rare	Nearshore waters	Year-round in northern range, Sept-late May in southern range; common from eastern Canadian Arctic and Greenland to southern NE and NY, occasionally south to Carolinas	N/A
Harp Seal *Phoca groenlandica* (Western North Atlantic)	NL	N/A / 7.1 million[5]	Rare	Highly migratory	Late Sept southern migration along the Labrador coast. Southern limit extends into U.S. from ME to NJ from Jan-May	N/A

Species (*Stock*)	**U.S. Federal Status (Stock Status)[1,2]**	**Regional/SAR Abundance Estimates[3]**	**Relative Occurrence in Atlantic Ocean[4]**	**Preferred Habitat in Atlantic Ocean***	**Seasonal Occurrence in Western Atlantic Area of Interest (AOI)****	**Critical Habitat in the AOI**
Gray Seal *Halichoerus grypus* (Western North Atlantic)	NL	N/A / 331,000[17].	Rare	Nearshore waters	Year-round in northern range, Sept-May in southern range; Common from ME to MA, occasionally south to NJ	N/A
Hooded Seal *Cystophora cristata* (Western North Atlantic)	NL	N/A / 592,100[5]	Rare	Highly migratory, deeper waters, offshore	winter/spring southernmost migration point Gulf of St. Lawrence for breeding; Jan-May seals of unknown stock in NE waters; summer-autumn off southeast U.S. coast	N/A

[1]Stock statuses are taken from the latest stock assessment report on the species from NOAA Fisheries at http://www.nmfs.noaa.gov/pr/sars/species.htm. Some stock assessment reports were not updated in Waring et al. (2015), making the most recent report Waring et al. (2014).
[2]ESA = Endangered Species Act. Stocks listed as depleted under the Marine Mammal Protection Act (MMPA) are described as any stock that falls below its optimum sustainable population 16 U.S.C. § 1362(1)(A). The numeric threshold for optimum sustainable population (OSP) has been interpreted by NMFS as being above 0.6 K (i.e., greater than 60 percent of carrying capacity [K]). In other words, a stock that dropped in numbers to below 60 percent of K would qualify as "depleted" under the MMPA. The term "strategic stock" is defined as a marine mammal stock: (1) for which the level of direct human-caused mortality exceeds the Potential Biological Removal level; (2) which, based on the best available scientific information, is declining and is likely to be listed as a Threatened species under the Endangered Species Act of 1973 within the foreseeable future; or (3) which is listed as a Threatened species or Endangered species under the Endangered Species Act of 1973, or is designated as depleted under [the MMPA]. DL = Delisted, EN = Endangered, NL = Not listed under ESA, Not listed as depleted under MMPA, and not classified as a strategic stock. Strategic stocks are shown with (S).
[3]SAR (stock assessment report) abundance estimates are from the 2014 U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments (Waring et al. 2015) as noted, and regional abundance estimates are for the North Atlantic regions as noted.
[4]Regular = common; Rare = not common.
*Information taken from the BOEM PEIS (BOEM 2014a) or the NOAA Stock Assessment Reports list below for each species
**Information taken from the BOEM PEIS (BOEM 2014a)
[5] Estimate for the Western North Atlantic Stock (Waring et al. 2014, 2015)
[6] Estimate for the central and northeast Atlantic in 2001 (Pike et al. 2009)
[7] Best estimate for the North Atlantic in 2007 (IWC 2013)

[8] Estimate for the Northeast Atlantic in 1989 (Cattanach et al. 1993)
[9] Estimate for the Nova Scotia Stock (Waring et al. 2015)
[10] Best estimate for the North Atlantic in 2002–2007 (IWC 2013)
[11] Estimate for the Canadian East Coast Stock (Waring et al. 2015)
[12] Best estimate for the western North Atlantic in 1992–1993 (IWC 2013)
[13] Minimum estimate for the Gulf of Maine stock (Waring et al. 2015)
[14] Estimate for the North Atlantic (Whitehead 2002)
[15] Estimate for the North Atlantic Stock (Waring et al. 2015)
[16] Combined estimate for pygmy and dwarf sperm whales (Waring et al. 2014)
[17] Estimate for Canadian waters; there is no estimate for U.S. waters (Waring et al. 2015)
[18] Combined estimate for Mesoplodon spp. (Waring et al. 2015)
[19] Combined estimate for both long- and short-finned pilot whales in the central and eastern North Atlantic in 1989 (IWC 2013)
[20] Tens to low hundreds of thousands in the North Atlantic (Reeves et al. 1999)
[21] Estimates for the Offshore, Coastal and Estuarine Stocks (Waring et al. 2015)
[22] Estimate for the Western North Atlantic in 1998 (Waring et al. 2007) although the number of Clymene dolphins off the U.S. Atlantic coast is unknown in its most recent Stock Assessment Report (Waring et al. 2014).
[23] Estimate for the North Atlantic (Jefferson et al. 2008)
[24] Estimate for the Gulf of Maine/Bay of Fundy Stock (Waring et al. 2015)
[25] Waring et al. (2015) states "A review of the photo-ID recapture database as it existed on 25 October 2013 indicated that 465 individually recognized whales in the catalog were known to be alive during 2011. This number represents a minimum population size. This is a direct count and has no associated coefficient of variation;"
[26] Waring et al. (2014) states "Little is known about the population size of blue whales except for the Gulf of St. Lawrence area. From 1979 to the summer of 2009, a total of 440 blue whales was photo-identified mainly in the St. Lawrence estuary and northwestern Gulf of St. Lawrence (R. Sears, pers. comm.)."
[27] This estimate of abundance underestimates the total abundance of the population throughout its range because it is based on surveys in part of the range in 2011 (Waring et al. 2015); an estimate of abundance of 3,522 was determined using surveys conducted from the Scotian Shelf to Northern Labrador in July-Aug 2007, all of which is North of the proposed project area;; there are no surveys in the project area in winter and it is not known where most fin whales spend winter (Waring et al. 2015)

4.1 North Atlantic Right Whale

The ESA-endangered North Atlantic right whale occurs in the proposed survey area (Table 4-1). The North Atlantic right whale, formerly known as the Northern right whale, inhabits the Atlantic Ocean and belongs to the Western stock (formerly the Western North Atlantic stock). The Western stock of right whales primarily inhabits coastal waters from southeastern U.S. (Florida) to New England north to the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence (Jefferson et al. 2008; Waring et al. 2014) (Figure 2-1).

Research suggests that there are 6 major habitats or congregation areas for western North Atlantic right whales (Waring et al. 2013, Waring et al. 2014; Weinrich et al. 2000; BOEM 2014a; LGL 2014a) (Appendix A, Figure A 1):

1. The coastal waters of the southeastern U.S. (winter calving grounds, Florida and Georgia);
2. Great South Channel (spring calving grounds);
3. Georges Bank/Gulf of Maine (fall feeding grounds);
4. Cape Cod and Massachusetts Bays (late winter/spring feeding grounds and nursery grounds;
5. Bay of Fundy (summer/fall feeding grounds);
6. Scotian Shelf (summer/fall feeding grounds)

In addition, Jeffreys Ledge, off the coasts of Massachusetts, New Hampshire, and Maine, is considered an important fall feeding area and summer nursery area for these whales (Weinrich et al. 2000).

North Atlantic right whales are listed as endangered under the ESA, and are considered one of the most critically endangered large whale species in the world (Clapham et al. 1999; Weinrich et al. 2000; Jefferson et al. 2008; Waring et al. 2014; BOEM 2014a). Three critical habitat areas were designated for this species in 1994 (Figure 2-1, and Appendix A, Figure A 1):

1. Cape Cod Bay/Massachusetts Bay,
2. Great South Channel, and
3. Selected areas off the southeastern U.S. (59 FR 28793; LGL 2014a; BOEM 2014a; NMFS 2014).

In 2009, NMFS received a petition to revise the critical habitat areas designated as critical feeding and calving habitat and found that the petition contained substantial information indicating revision may be warranted (75 FR 61690). In April 2014, a coalition of environmental groups sued NMFS to expand right whale critical habitat. In October 2014, a settlement agreement was reached in which NMFS agreed to issue a proposed critical habitat rule in February 2015 and finalize the rule in February 2016. In February 2015, NMFS published a notice in the Federal Register of a proposed rule for revision to North Atlantic right whale critical habitat to include two new areas (80 FR 9314). One of these areas is in the Gulf of Maine, outside of the proposed seismic survey area, and one is in the southeastern U.S. extending from Cape Fear, NC southward to 29 ^{o}N (approximately 43 mi north of Cape Canaveral, FL), which contains the essential features necessary for right whale calving and covers approximately 8,611 nm^2 of habitat in water depths of 6-28 m. This rule has not been finalized as of the submission of this IHA application. Additionally, in

2009, Seasonal Management Areas (SMAs) for reducing ship collisions of North Atlantic right whales were designated in the U.S. (73 FR 60173; Conn and Silber 2013; BOEM 2014a) (Appendix A, Table A 1,). A Recovery Plan has been in effect for the North Atlantic right whale since 2005 (70 FR 32293; NMFS 2005b). In 2012, NMFS announced a new 5-year review goal (77 FR 15638) to recover the species, with an interim goal of down-listing their status from endangered to threatened (NMFS 2012a).

Other actions taken to protect North Atlantic right whales include:

1. Establishing the Right Whale Sighting Advisory System designed to reduce collisions between ships and right whales by alerting mariners to the presence of the whales (NEFSC 2012);
2. A Mandatory Ship Reporting System implemented by the U.S. Coast Guard in the right whale nursery and feeding areas (64 FR 29229; 66 FR 58066; Ward-Geiger et al. 2005);
3. Recommended shipping routes in key right whale aggregation areas (NOAA 2006, 2007, 2013a);
4. Regulations to implement seasonal mandatory vessel speed restrictions in specific locations (SMAs) during times when whales are likely present, including ~37 km around points near the Ports of New York/New Jersey (40.495ºN, 73.933ºW) and Philadelphia and Wilmington (38.874ºN, 75.026ºW) during 1 November–30 April (73 FR 60173);
5. Temporary Dynamic Management Areas (DMAs) in response to actual whale sightings, requiring gear modifications to traps/pots and gillnets in areas north of 40°N with unexpected right whale aggregations (NOAA 2012);
6. A voluntary seasonal (April 1 to July 31) area to be avoided in the Great South Channel off Massachusetts (NOAA 2013a).

The southeast SMA is a continuous area that extends 37 km from the shoreline from St. Augustine, Florida, to Brunswick, Georgia (NMFS 2014). The Mid-Atlantic SMA is a combination of both continuous and 20 km arcs around the entrances to certain bays and ports (NMFS 2014). DMAs are designed to reduce the risk of whale-ship interactions when right whale(s) are found aggregating in an area (NMFS 2014) (Figure 2-1).

Sightings of small groups or individuals have been reported in the survey area as far south as Florida (CETAP 1981, 1982; Baumgartner and Mate 2005; Kenney 2007; Ward-Geiger et al. 2011; DoN 2013; Schick et al. 2013). The mid-Atlantic region has been identified as a primary migratory corridor for North Atlantic right whales (Knowlton et al. 2002; Firestone et al. 2008). Seasonal north-south migration of the Western stock occurs between feeding and calving areas, but right whales could be seen anywhere off the Atlantic U.S. throughout the year (Gaskin 1982; LGL 2014a). Seasonal occurrence of right whales in mid-Atlantic waters is normally during November through April, with peaks in December and April (Winn et al. 1986) when whales are migrating to and from breeding/feeding grounds.

The southeastern U.S. Atlantic coast is a principal calving area for North Atlantic right whales (Ward-Geiger et al. 2011). Parturient females migrate to waters off the southeastern U.S. to give birth in the late fall or early winter (Kraus et al. 1986; Cole et al. 2013). During intensive aerial surveys conducted during December through March of 2007 off Florida, Georgia, and South and North Carolina, most mothers of the year were detected (Kraus et al. 2007; Cole et al. 2013). In early spring, mothers and calves migrate north and return to feeding grounds in the Gulf of Maine (Kraus et al. 1986; Hamilton and Mayo 1990; Cole et al. 2013).

The species has been documented seasonally in the survey area within the JAX Range Complex, primarily from mid-November through March, although individuals have been seen off the southeastern U.S. as late as July (NMFS 2007). Sightings and acoustic detections have been concentrated in continental shelf waters offshore northeastern Florida and southeastern Georgia (DoN 2008; Norris et al. 2012). Three right whales were sighted with propeller wounds between November 2012 – October 2013 off Georgia, Florida and the Mid-Atlantic (Pettis 2013). Northern Atlantic right whales are considered regular inhabitants of the AOI (BOEM 2014a).

North Atlantic right whale abundance estimates have slowly increased over the past two decades, with a geometric mean growth rate of 2.68 percent with the most recent minimum population size estimate at 465 (Waring et al. 2015).

Right whales produce sounds that generally range in frequency from approximately 200 Hertz (Hz) to 15 kHz (Parks and Tyack 2005; Parks et al. 2005, 2007a,b). They are known to produce at least 3 primary sound types (Vanderlaan et al. 2003; Parks et al. 2005; Parks and Tyack 2005; Parks et al. 2007a,b):

1. ‘blow sounds’ that coincide with exhalation;
2. ‘broadband impulsive sounds’ including slaps and the ‘gunshot’ call (thought to be produced exclusively by males);
3. ‘tonal call types’ including stereotyped and complex, variable frequency-modulated (FM) calls such as the upcall and downcall.

Additionally, during fall and winter months, North Atlantic right whale gunshot calls and downsweeps have been detected in recordings made from Marine Autonomous Recording Units (MARUs) deployed along the continental shelf break approximately 120 km offshore of Jacksonville, Florida (Norris et al. 2012; DoN 2013).

4.2 Blue Whale

The ESA-endangered blue whale is unlikely to occur in the survey area except as an occasional pelagic migrant (Table 4-1). Blue whales in the U.S. Atlantic waters belong to the Western North Atlantic stock. Although their distribution extends as far north as the Arctic south to Cape Cod, they are most commonly seen off eastern Canada (Waring et al. 2011; BOEM 2014a). The blue whale is listed as endangered under the ESA but no critical habitat is designated. In 2012, NMFS announced a notice of intent to update the 1998 recovery plan for the blue whale (NMFS 1998; 77 FR 22760).

Blue whales are occasionally found in waters of the Atlantic EEZ, which is believed to be the current southern limit of its feeding range (CETAP 1982; Wenzel et al. 1988; Waring et al. 2011). Although the southern limit of the species’ range is unknown, this species has occurred off Florida and the in the Gulf of Mexico (Yochem and Leatherwood 1985; Waring et al. 2011). The minimum population estimate for this stock is 440 based on photo-identified individuals catalogued between 1979 and the summer of 2009 (Waring et al. 2011). Blue whale A and B calls have been detected from late August through October offshore of Onslow Bay, North Carolina in recordings made using High Frequency Acoustic Recording Packages (HARPs) (Debich et al. 2014).

4.3 Fin Whale

The ESA-endangered fin whale occurs frequently in northern U.S. Atlantic EEZ waters (Waring et al. 2014). Based on limited information, the IWC considers fin whales in the North Atlantic to all belong to the same stock (Waring et al. 2014). However, there is additional evidence that supports establishment of subpopulations in the North Atlantic (Mizroch et al. 1984; Jefferson et al. 2008; Waring et al. 2014). Fin whales in the North Atlantic currently belong to the Western North Atlantic stock. NMFS published a recovery plan for the fin whale in 2010 (NMFS 2010a). The fin whale is listed as endangered under the ESA although no critical habitat is designated. Fin whales are being considered for downlisting from endangered to threatened due to the increase in the population worldwide (NMFS 2010a).

Fin whales are typically found in waters of the Atlantic EEZ, with some sightings as far south as Cape Hatteras, North Carolina, northward to Maine (Waring et al. 2014). New England waters tend to be the feeding grounds for the fin whale and it is believed that whales on these grounds exhibit patterns of seasonal occurrence and annual return (Seipt et al. 1990; Clapham and Seipt 1991; Waring et al. 2014). However, Watkins et al. (2000) reports that fin whales may not make large seasonal movements like other baleen whales. Fin whales were present in Bermuda early September through mid-May (Clark and Gagnon 2004) and in the mid-ocean near the Mid-Atlantic ridge late fall through early winter (BOEM 2014a).

Reported sightings of fin whales north of the proposed seismic survey area are numerous as documented within the OBIS-SEAMAP database (e.g., CETAP 1982; Halpin et al. 2009; Paxton 2013; HDR 2013; DoN 2013). It is considered the most dominant large cetacean species within New England and New Jersey shelf waters during all seasons (CETAP 1982; NMFS 2010a; Waring et al. 2014). Geo-Marine Inc. (GMI) (2010) reported frequent year-round sightings of fin whales during shallow-water (< 30 m) surveys on the New Jersey continental shelf in January 2008–December 2009. Three fin whales stranded off South and North Carolina between 1997 and 2008 (Byrd et al. 2014). Additionally, fin whales have been detected in HARP recordings offshore of Onlsow Bay, North Carolina (160 km) from November to April and offshore of Jacksonville, Florida (80-98 km) in January and February in water depths of 950 m and 40 and 300 m, respectively (Debich et al. 2013, 2014).

Fin whale abundance estimates have varied depending on where surveys were conducted (surveys do not include the entire range of Western North Atlantic fin whales). Only 23 (CV 0.87) fin whales of the greater total population were estimated to occur between central Virginia and Central Florida based on shipboard surveys in summer 2011 (Waring et al. 2015). Data for the fin whale are insufficient to inform population trends (Waring et al. 2015).

4.4 Sei Whale

Sei whales are unlikely to be encountered in the survey area, although small numbers have been documented there during late fall and winter (McLellan 2010). In the North Atlantic

Ocean, there are 2 recognized populations of sei whales: the Nova Scotia and Labrador Sea stocks (Mitchell and Chapman 1977; Waring et al. 2014). Only the Nova Scotia stock inhabits waters off the U.S. northeastern coast, from the continental shelf northeastward to south of Newfoundland (Waring et al. 2014; BOEM 2014a). Sei whales tagged off of the Azores Islands indicated a migratory corridor between the Azores and the Labrador Sea (Prieto et al. 2014). These data also indicated discrete feeding ground in the Gulf of Maine and off Nova Scotia (Prieto et al. 2014). The sei whale is listed as endangered under the ESA although no critical habitat is designated. A recovery plan for the sei whale was published in 2011 (NMFS 2011).

Typically, sei whales inhabit deep water along continental slopes and shelf breaks (Hain et al. 1985; Horwood 1987; Waring et al. 2014). They are considered common summer residents in the northern portions of the U.S. Atlantic EEZ, mainly the Gulf of Maine and Georges Bank (Waring et al. 2013). The highest numbers of sei whale are seen in U.S. waters during spring concentrated along the eastern margin of Georges Bank and into the Northeast Channel area, and along the southwestern edge of Georges Bank in the area of Hydrographer Canyon (CETAP 1982; Waring et al. 2014). Sightings of small groups or individuals have been reported in the survey area during November – February (CETAP 1981, 1982; McLellan 2010). Sei whales have been detected in recordings made using HARPs deployed offshore of Jacksonville, Florida (80 – 97 km and 40 and 300 m depths) and Onslow Bay, North Carolina (161 km and 950 m depth) during winter months (Debich et al. 2014; 2013).

The Nova Scotia stock population, like all large whale populations, was once hunted to near extinction, and there is no current population estimate for the western North Atlantic Ocean sei whale. The Nova Scotia population is currently estimated at 357 whales (Waring et al. 2014), a decrease from the last estimate of 386 in 2004 (Waring et al. 2012). However, estimates are considered conservative because the entire known range of the sei whale has not been completely surveyed (Waring et al. 2014).

4.5 Bryde's Whale

Bryde's whales are considered highly unlikely to occur in the survey area (BOEM 2014a) as they typically occur farther south and in small numbers (Table 4-1). Bryde's whales occurring in the western Atlantic Ocean are not classified within a management stock (Schmidly 1981; Leatherwood and Reeves 1983; Waring et al. 2013; BOEM 2014a). The Gulf of Mexico (GoM) population is temporarily being regarded a separate stock for management purposes, although there is currently no information to distinguish this stock from the Atlantic Ocean stock(s) (Waring et al. 2013). The species is not listed as threatened or endangered by the ESA; however a petition has been submitted to list Bryde's whales in the GoM as endangered, and NOAA recently made a 90 day finding that will result in a status review of this species (80 FR 18343).

Bryde's whales have been reported in southeastern U.S. Atlantic waters of the survey area (Virginia to Florida) and through the southern West Indies to Brazil (Leatherwood and Reeves 1983; Cummings 1985; Waring et al. 2013; BOEM 2014a). The AOI and thus the survey area in the southeastern U.S. Atlantic are considered to be a "secondary range" for this species (Jefferson et al. 2008; BOEM 2014a). Although Rice (1978) has been cited by the IUCN Redlist (http://www.iucnredlist.org/details/2476/0) and the NRDC petition to list Bryde's whales in the Gulf of Mexico as endangered (http://docs.nrdc.org/wildlife/files/wil_14091701a.pdf) as documentation for at least 1 sighting of Bryde's whales near Cape Hatteras, NC, this is not stated in Rice (1978). Mead (1977) reports a stranding of a Bryde's whale in Walnut Point, VA in the late 1920's, as well as a 3 historical strandings in Florida. Roberts et al. (2015) report that SEFSC surveys have recorded 4 Bryde's whales in the Western North Atlantic U.S. EEZ in a total of 1,039,000 km of survey effort in the area from 1992-2014, indicating this species is very rare in the region.

4.6 Common Minke Whale

Small numbers of minkes are expected to occur in the survey area, primarily during winter (e.g., Norris et al. 2012; Dominello et al. 2013; DoN 2013). In the North Atlantic Ocean, there are 4 recognized populations of common minke whales: Canadian East Coast, west Greenland, central North Atlantic, and northeastern North Atlantic (Donovan 1991; Waring et al. 2014). The stock that inhabits waters within the survey area off the U.S. eastern coast is the Canadian East Coast stock, distributed from the Davis Strait (45°W) to the GoM (Waring et al. 2014; BOEM 2014a).

The common minke whale ranges widely within the U.S. Atlantic EEZ typically in continental shelf waters (CETAP 1982; Waring et al. 2014). The Canadian East Coast stock is thought to winter in the West Indies, and in the mid-ocean south and east of Bermuda (Mitchell 1991; Waring et al. 2014). During summer months, the stock migrates north to New England and Canadian waters (Waring et al. 2014).

The Canadian East Coast stock has been steadily increasing in numbers as documented over the past two decades. Abundance estimates almost tripled from approximately 3,300 to 8,900 whales during 2006 and 2007 surveys (Waring et al. 2013). An abundance estimate of 2,591 individuals was generated from a shipboard and aerial survey conducted during June-August 2011 (Palka 2012) covering the area from central Virginia to lower Bay of Fundy (Waring et al. 2014). The overall most recent population estimate for the North Atlantic is 20,741 (Waring et al. 2014).

Based on aerial and vessel surveys, a small number of individual minkes have been documented in or near the survey area waters during winter (CETAP 1981, 1982; McLellan 2010; Nilsson et al. 2010; DoN 2011, 2012; Norris et al. 2012; Palka 2012; Dominello et al. 2013; DoN 2013). Minke whale vocalization events were detected almost daily during winter deployment of MARUs in the U.S. Navy's Undersea Warfare Training Range approximately 60 150 km off Jacksonville, Florida (DoN 2013). The minke was the most frequently (about 53 percent) recorded cetacean species during the winter. The recordings were based on the number of acoustic events (~53 percent) predominately at deep-water recording sites (1,000 m). Minke whales have also been detected regularly during winter months with HARPs recordings off Jacksonville, Florida and Onslow Bay, North Carolina (Debich et al. 2013, 2014).

4.7 Humpback Whale

Humpback whales are expected to been seen in the survey area in relatively small numbers seasonally during migrations (Table 4-1). Within the Atlantic Ocean there are 6 discrete subpopulations of humpback whales: the Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland (Katona and Beard 1990), Iceland and northern Norway (including off Bear Island and Jan Mayen) (Katona and Beard 1990; Christensen et al. 1992; Palsbøll et al. 1997; Waring et al. 2014). The Gulf of Maine stock, formerly known as the Western North Atlantic stock, inhabits waters off the U.S. eastern coast and is treated as a separate management unit (Waring et al. 2014). The humpback whale is listed as endangered under the ESA though no critical habitat is designated for this species. NMFS published a recovery plan for this species in 1991 (NMFS 1991). NOAA published an updated status review of humpback whales in 2015 (Bettridge 2015) and has proposed to split humpbacks into 14 DPSs under ESA (80 FR 22304). Under this proposed rule, humpback whales in the DPS associated with the North Atlantic (West Indies DPS) would not be listed under ESA (80 FR 22304).

The humpback whale ranges widely within the U.S. Atlantic, typically in continental shelf and oceanic island waters (Waring et al. 2014; BOEM 2014a). In the Gulf of Maine, some individuals are found year-round (Waring et al. 2014; BOEM 2014a). Others migrate to the West Indies during the winter to mate (Waring et al. 2014). During summer months, the stock migrates north to New England and Canadian waters (Waring et al. 2014).

The area proposed for WesternGeco's 2D seismic program is not within normal humpback whale feeding or migration areas. However, sightings have been reported off Delaware, Virginia, North Carolina, and Florida during the fall and winter (Swingle et al. 1993; Barco et al. 2002; Norris et al. 2012; DoN 2013; BOEM 2014a; Johnson et al. 2014). These data suggest that the Mid-Atlantic region may also serve as wintering grounds for some Atlantic humpback whales (BOEM 2014a). Additionally, non-song signals from humpback whales have been detected infrequently during March and April in HARP recordings off Jacksonville, Florida and Onslow Bay, NC, respectively (Debich et al. 2013, 2014).

The most recent minimum population estimate for the Gulf of Maine stock was 823 in 2011 (Palka 2012; Waring et al. 2014). An abundance estimate of 335 individuals was generated from a shipboard and aerial survey conducted during June-August 2011 (Palka 2012, Waring et al. 2014). This estimate covers the area from central Virginia to lower Bay of Fundy (Waring et al. 2014).

4.8 Sperm Whale

Sperm whales occur regularly in the survey area in offshore deep pelagic waters primarily in fall and winter (Table 4-1). Sperm whales in the North Atlantic belong to the North Atlantic Stock and are distributed along the U.S. EEZ (Waring et al. 2014) on the continental shelf edge, over the continental slope, and into mid-ocean regions (Davis et al. 2002; Waring et al. 2014). The sperm whales that occur in the eastern U.S. Atlantic EEZ most likely only represent a fraction of the total stock (Waring et al. 2014). It is currently undecided whether the northwestern Atlantic population is separate from northeastern Atlantic population (Waring et al. 2014; BOEM 2014a). However, the International Whaling

Commission (IWC) discerns only 1 stock for the North Atlantic (Borrell et al. 2013; Waring et al. 2014). Genetic evidence suggests sperm whales may have a global population, though females show some philopatry (Lyrholm et al. 1999). The sperm whale is listed as endangered under the ESA though no critical habitat is designated for this species (NMFS 2010b). NMFS published a recovery plan for this species in 2010 (NMFS 2010b).

During winter, sperm whales concentrate east and northeast of Cape Hatteras, North Carolina (Waring et al. 2014; BOEM 2014a). In the spring, they shift northward to waters off Delaware and Virginia and are widespread throughout the MAB and the southern portion of Georges Bank (Waring et al. 2014; BOEM 2014a). In summer, similar to winter, sperm whales also inhabit the area east and north of Georges Bank and the Northeast Channel region, and the continental shelf south of New England (Waring et al. 2014). By fall, sperm whales are most common south of New England on the continental shelf and shelf edge in the MAB (Waring et al. 2014; BOEM 2014a).

The North Atlantic stock of sperm whales is estimated at 2,288 individuals based on a 2011 survey on the continental shelf edge and continental slope areas (Waring et al. 2014). Sperm whales have been sighted regularly in the Mid- and South Atlantic planning areas, especially off Florida and North Carolina (Waring et al. 1993, 2001; Waring 1998; Hansen et al. 1994; Engelhaupt et al. 2009; Norris et al. 2012; DoN 2013).

Sperm whales have been detected acoustically in both fall and winter off Jacksonville, Florida and Onslow Bay, North Carolina. Detections occurred almost exclusively on autonomous recorders deployed near the continental shelf break and primarily between dawn and dusk (Hodge 2011; Norris et al. 2012; Hodge et al. 2013; Debich et al. 2014). In Onslow Bay, sperm whales clicks have been heard on depth recorders (Hodge et al. 2013). Sperm whales were also detected year-round offshore of Cape Hatteras, North Carolina from recordings made using a HARP (Stanistreet et al. 2013). Unlike the recording made off Jacksonville, there was no diel pattern detected for sperm whales at this site (Stanistreet et al. 2013).

4.9 Pygmy and Dwarf Sperm Whales

Both the pygmy and dwarf sperm whales may occur year-round in small numbers in deep offshore waters of the survey area (Table 4-1). Both species within the western North Atlantic belong to the Western North Atlantic stock but with a pooled abundance estimate due to difficulty in differentiating at sea (Waring et al. 2014). These animals occur in oceanic waters (Mullin and Fulling 2003). The western North Atlantic *Kogia* spp. population is considered a separate stock for management purposes, although there is currently no information to differentiate this stock from the northern Gulf of Mexico stock (Waring et al. 2014).

Migration patterns and the seasonality of pygmy and dwarf sperm whales are unknown (Waring et al. 2014). Sightings of these species have occurred over the continental shelf edge and slope from Maine to Florida (Bloodworth and Odell 2008; Waring et al. 2014; Staudinger et al. 2014). Although the 2 species overlap in their distribution, there is some evidence of resource partitioning between the two (Willis and Baird 1998; Wang et al. 2002; Barros and Duffield 2003; Plön 2004; Staudinger et al. 2014). *Kogia* species have been acoustically detected off Cape Hatteras and Onslow Bay in recordings made using HARPs (Debich et al. 2014; Stanistreet et al. 2013; Hodge 2011). *Kogia* echolocation clicks can be distinguished from other odontocete species based on the frequency range of the clicks, however, they cannot be assigned to specific *Kogia* species. *Kogia* spp. have been seen during surveys off the Florida and North Carolina coasts (Hansen et al. 1994; DoN 2013).

4.10 Northern Bottlenose Whale

The northern bottlenose whale is considered rare in the survey area based on the low number of encounters in U.S. Atlantic waters where it is limited to deep pelagic waters mainly during spring and summer (Waring et al. 2008) (Table 4-1). Those in the western Atlantic are considered to be from the Western North Atlantic stock, and are considered rare in U.S. Atlantic waters (Waring et al. 2009). They are rarely encountered in water < 2,000 m deep (Waring et al. 2009).

Northern bottlenose whales range predominantly from the Northeastern U.S. or Nova Scotia to Davis Strait and Greenland (CETAP 1982; Wimmer and Whitehead 2004; Macleod et al. 2006; Waring et al. 2009). However, they are occasionally found as far south as New Jersey (Wimmer and Whitehead 2004). Insufficient data exist to determine a stock abundance estimate for this species in the Western North Atlantic, and they are not commonly seen during surveys in U.S. waters.

Single animals were recorded in both 1993 and 1996 along the southern edge of Georges Bank (NMFS 1993, 1996). Two northern bottlenose whales were seen off the coast of New Jersey in 1981 (Wimmer and Whitehead 2004), and 1 individual was recorded during a study of marine mammal interaction with pelagic longline fishing gear between Florida and Cape Cod from 1992 to 1994 (Garrison 2007).

4.11 Beaked Whales

Five species of beaked whales occur year-round in small numbers within the survey area, all of which are generally found in deep offshore waters (Waring et al. 2014):

1. Cuvier’s beaked whale,
2. Blainville's beaked whale,
3. Gervais' beaked whale,
4. Sowerby's beaked whale,
5. True's beaked whale.

The 5 species of beaked whales are separated into unique management stocks (BOEM 2014a), but the *Mesoplodon* spp. have a pooled abundance for the Western North Atlantic and Gulf of Mexico due to difficulty in differentiating at sea. Western North Atlantic Cuvier’s beaked whales are evaluated separately from the *Mesoplodon* spp. (Waring et al. 2013).

Cuvier’s and *Mesoplodon* spp. beaked whales occurring in the northwest Atlantic have usually been along the continental shelf edge in the Mid-Atlantic region as far north as Nova Scotia and south to central Florida, with most occurring from Massachusetts to central Florida (CETAP 1982; MacLeod et al. 2006; Palka 2012; Waring et al. 2014; BOEM 2014a; LGL 2014a; Bryd et al. 2014). The distribution of *Mesoplodon* spp. in the western North

Atlantic is known from stranding records (Mead 1989; Nawojchik 1994; Mignucci-Giannoni et al. 1999; MacLeod et al. 2006; Jefferson et al. 2008). Available data from the northwest Atlantic suggest that beaked whales are rare in winter and fall, common in spring and most abundant in summer in waters north of Virginia, off the shelf break and over the continental slope (DoN 2005, 2008; LGL 2014a). Recent aerial and shipboard surveys have shown *Mesoplodon* spp. offshore in the Onslow Bay survey area between the 1,000- and 2,000-m isobaths (DoN 2013). Survey effort off Cape Hatteras has shown an abundance of beaked whale sightings off the continental shelf break (DoN 2013).

The stock structure for the Cuvier's beaked whale belonging to the Western North Atlantic Stock is unknown (Waring et al. 2014). Although, these 5 species occur regularly in the AOI, and thus the survey area, densities and abundances are considered to be relatively low there (Table 4-1).

Passive acoustic monitoring (PAM) (using HARPs) was conducted within the U.S. Navy's Cherry Point OPAREA during August – December 2011 and July – October 2012 approximately 160 km off the North Carolina shelf break at a depth of 950 m. Cuvier's, Blainville's, and Gervais beaked whales were detected throughout the recording periods. Cuvier's and Blainville's beaked whales were detected less frequently than Gervais beaked whales with detections peaking in November (Debich et al. 2014). Gervais beaked whales were detected regularly throughout the recording deployment periods (Debich et al. 2014). Cuvier's beaked whales and Gervais beaked whales were also detected in March and April offshore of Cape Hatteras, North Carolina with HARPs deployed between March and October 2012 at depths of approximately 950 m (Stanistreet et al. 2013).

4.12 Killer Whale

The killer whale is considered rare in the survey area (Table 4-1). Killer whales occurring in the western North Atlantic are from the Western North Atlantic stock (Waring et al. 2000; BOEM 2014a) and are considered uncommon or rare in waters of the U.S. Atlantic EEZ (Katona et al. 1988; Waring et al. 2000; BOEM 2014a). Killer whales in the northwest Atlantic occur from the polar ice pack to Florida and the Gulf of Mexico (Würsig et al. 2000; LGL 2014a).

Killer whales have most often been found along the shelf break and offshore in the northwest Atlantic based on historic sightings and strandings (Katona et al. 1988; Mitchell and Reeves 1988; LGL 2014a). While their occurrence is unpredictable in the U.S. Atlantic EEZ, they sometimes occur in fishing areas, possibly coincident with tuna during warm seasons (Katona et al. 1988; Waring et al. 2000; BOEM 2014a). The population size of killer whales off the eastern U.S. coast is unknown (Waring et al. 2000). Killer whales have been present in the Mid-and South Atlantic planning areas, particularly New Jersey, New York and North Carolina (Winn 1982; CETAP 1982; Hansen et al. 1994; Hairr 2012).

Killer whale calls have been detected acoustically in the Cherry Point OPAREA (offshore of Cape Hatteras) and within the JAX Range Complex (Hodge 2011; DoN 2013; Debich et al. 2014).

4.13 Pilot Whale

Two species of pilot whales inhabit the western Atlantic and occur in the survey area during winter and spring—the long-finned pilot whale and the short-finned pilot whale. Due to the difficulty of differentiating them at sea, they are often reported as *Globicephala* spp. (Waring et al. 2012; BOEM 2014a). Pilot whales in the western Atlantic belong to the Western North Atlantic Stock and are broken up into short-finned and long-finned stocks (Waring et al. 2012).

Pilot whales are distributed along the continental shelf edge off the northeastern U.S. Atlantic coast in winter and early spring (CETAP 1982; Mullin and Fulling 2003; Waring et al. 2012). They move onto Georges Bank and into the Gulf of Maine and more northern waters in late spring, and remain there during late autumn (CETAP 1982; DoN 2005; Waring et al. 2012; LGL 2014a). Long-finned and short-finned pilot whale ranges overlap along the shelf break between Cape Hatteras, North Carolina, and New Jersey (Waring et al. 2012; LGL 2014a). Pilot whales have been present in the Mid-and South Atlantic planning areas, especially off Florida, Georgia, North and South Carolina, and Virginia (CETAP 1982; Palka 2012; DoN 2013; Byrd et al. 2014). The best available population estimates for short-finned and long-finned pilot whales in the North Atlantic are presented in Table 4-1.

Pilot whale vocalizations have been detected in the waters of the Mid-and South Atlantic planning areas (Hodge 2011; Debich et al. 2014).

4.14 False Killer Whale

False killer whales are considered rare in U.S. Atlantic EEZ waters and thus the survey area (Table 4-1). A false killer whale stock assessment report for a Western North Atlantic stock was first produced in 2014 (Waring et al. 2015). Prior to 2015, false killer whales occurring in the western North Atlantic were considered to be from the Gulf of Mexico stock (Waring et al. 2013; BOEM 2014a).

False killer whales are found in deep oceanic areas, though they are known to occur on the continental shelf and shelf edge (Baird 2002; Jefferson et al. 2008). Nearshore and continental shelf waters are considered a secondary range of false killer whales (Jefferson et al. 2008). Very few sightings of false killer whales have occurred in the Mid-and South Atlantic planning areas and there is insufficient data to determine trends within the AOI (Waring et al. 2015; BOEM 2014a). According to OBIS-SEAMAP, there have only been 6 sightings within the Mid-and South Atlantic planning areas off Virginia, North Carolina, and Florida. One sighting occurred during the CETAP surveys in 1982 off Cape Hatteras (CETAP 1982). During cetacean abundance surveys in the winter of 1992, 1 sighting occurred off Cape Hatteras (Hansen et al. 1994). Surveys in 2011 resulted in one sighting of 11 individuals (Waring et al. 2015). False killer whales are not likely to be seen in the survey area based on available data.

4.15 Pygmy Killer Whale

Pygmy killer whales are considered rare or uncommon in pelagic waters of the U.S. Atlantic EEZ and thus the survey area (Table 4-1). Those that inhabit the western Atlantic are considered to belong to the Western North Atlantic Stock and are found primarily in deeper waters (Waring et al. 2007). Population numbers of pygmy killer whales off the U.S. Atlantic coast are unknown; therefore, seasonal abundance estimates are not available for this stock (Waring et al. 2007). One sighting of 6 pygmy killer whales occurred in 1992 during a survey in the western North Atlantic off Cape Hatteras, North Carolina (Hansen et al. 1994; Waring et al. 2007).

4.16 Melon-headed Whale

Melon-headed whales are considered rare or uncommon in waters of the U.S. Atlantic EEZ (Waring et al. 2007), and thus the survey area. Those in the western Atlantic are considered to belong to the Western North Atlantic Stock (Waring et al. 2007) and are primarily found in oceanic waters.

Seasonal distribution and abundance of the melon-headed whale off the U.S. Atlantic coast are unknown, and there are insufficient data to determine population numbers (Waring et al. 2007). Two groups of melon-headed whales were spotted during vessel surveys of the western North Atlantic off Cape Hatteras, North Carolina in 1999 (20 individuals) and 2002 (80 individuals) (NMFS 1999, 2002; Waring et al. 2007). Both groups occurred in oceanic waters with water depths of >2,500 m. During aerial surveys off Cape Hatteras conducted between May 2011 and May 2012, there were 2 sightings of melon-headed whales totaling 395 individuals (DoN 2013).

4.17 Rough-toothed Dolphin

Rough-toothed dolphins are considered rare in U.S. Atlantic EEZ waters and thus the survey area, occurring mainly off the southeastern U.S. (Table 4-1). Those occurring in the western Atlantic are considered to be from the Western North Atlantic Stock (Waring et al. 2009). Rough-toothed dolphins are primarily seen in deep oceanic waters; however, they may also occasionally occur in shallow waters (Waring et al. 2009).

Insufficient data exist to determine a population estimate for this stock, and the seasonal distribution and abundance is unknown (Waring et al. 2009). This species is also not commonly encountered during surveys; however, recent evidence suggests this species occurs in the AOI as follows:

- Eight rough-toothed dolphins were recorded during a shipboard line-transect sighting survey south of Maryland between 8 July - 17 August 1998 (Mullin and Fulling 2003).
- Three rough-toothed dolphins were observed during a shipboard line-transect survey north of Maryland between 6 July and 6 September 1998 (Palka 2006).
- During a vessel survey of waters over 2500 m deep off Cape Hatteras, North Carolina, a group of 4 rough-toothed dolphins was seen in August 1999, and a group of 20 was recorded in September 1999 (NMFS 1999).
- During an aerial survey off Cape Hatteras area between May 2011 and May 2012, one group of 4 rough-toothed dolphins was recorded (DoN 2013).
- Four groups of rough-toothed dolphins were recorded during a vessel survey from June to August 2011 covering waters from North Carolina to the lower Bay of Fundy, all where water depths was deeper than 2000 m (Palka 2012).

Rough-toothed dolphins were also recorded both visually and acoustically during summer and winter 2011 aerial and vessel surveys covering the U.S. Atlantic waters to the lower Bay of Fundy (Northeast Fisheries Science Center [NEFSC] and Southeast Fisheries Science Center [SEFSC] 2011).

4.18 White-beaked Dolphin

The white-beaked dolphin is not likely to be encountered in the survey area based on a review of available data (Table 4-1). Those in the western Atlantic are considered to be from the Western North Atlantic stock (Waring et al. 2007). They are primarily distributed from southern New England to southern Greenland (Leatherwood et al. 1976; CETAP 1982; Waring et al. 2007), and their migration patterns are relatively unknown (Leatherwood et al. 1976). Prior to the 1970s, white-beaked dolphins were found predominantly in shelf waters, while white-sided dolphins were found primarily offshore on the continental slope. However, in the 1970s habitat use by these 2 species switched, potentially due to an increase in sand lance (*Ammodytes* spp., a major food source for white-sided dolphins) on the continental shelf (Katona et al. 1993, Kenney et al. 1996).

The exact number of white-beaked dolphins in the western Atlantic is unknown, and no current reliable stock abundance estimate exists. An estimated 2,003 dolphins was calculated from an August 2006 aerial survey from southern Georges Bank to the upper Bay of Fundy; however, it is not considered an accurate estimate as it only covered part of the species' known range (Waring et al. 2007). Reported sightings of white-beaked dolphin in the survey area and surrounding region are documented within the OBIS-SEAMAP database. In 1979, 15 sightings were seen off the coast of North Carolina during vessel and aerial surveys on the continental shelf (CETAP 1981). Similar aerial surveys were conducted in 2002 and 2004; however, no white-beaked dolphins were recorded (Waring et al. 2007). The best available population estimate for this species in the North Atlantic is presented in Table 4-1.

White-beaked dolphins are occasionally seen during surveys in Atlantic U.S. waters. During a 2012 survey from southern Florida to Nova Scotia, 1 group of 6 white-beaked dolphins was recorded during spring vessel and aerial surveys off of Maine (NEFSC and SEFSC 2012). One group of 4 individuals was recorded during a fall aerial survey conducted in the same region (NEFSC and SEFSC 2012). Based on the sightings data for white-beaked dolphins it is possible, but not likely, that this species will be encountered during the proposed activities.

4.19 Atlantic White-sided Dolphin

Atlantic white-sided dolphins are expected to occur in the survey area based on the frequency and regularity of sightings in the U.S. Atlantic EEZ (Table 4-1). Those in the western Atlantic are considered to be from the Western North Atlantic stock (Waring et al. 2013). Evidence suggests this stock may actually be 3 stock units: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea (Palka et al. 1997). White-sided dolphins in the survey area are expected to be mainly from the Gulf of Maine population, and are found most commonly along the continental shelf (Waring et al. 2013).

White-sided dolphins occur year-round between North Carolina and the lower Bay of Fundy (Waring et al. 2013). From January to May, they can be found north of the survey area, in lower numbers off Georges Bank to Jeffreys Ledge and in even lower numbers south of Georges Bank (Waring et al. 2013). They occur in large numbers from Georges Bank north to the Bay of Fundy in June through September, and in intermediate numbers between Georges Bank north to the southern Gulf of Maine from October to December (Waring et al. 2013). The seasonal distribution of this species appears to have changed over the last few years (Waring et al. 2013). The exact number of Atlantic white-sided dolphins in the U.S. Atlantic EEZ is unknown; however, there have been many abundance estimates from various portions of their range between 1978 and 2011 (Waring et al. 2013). The most current best estimate of abundance for the Western North Atlantic stock is 48,819 based on vessel and aerial surveys conducted between June and August 2011 north of North Carolina (Palka 2012; Waring et al. 2013).

An aerial survey in August 2006 covering waters between southern Georges Bank north to the Bay of Fundy resulted in an abundance estimate of 17,594 (Waring et al. 2013). An aerial and vessel survey between June and August 2004 between Georges Bank to the lower Bay of Fundy resulted in an abundance estimate of 2,330 (Waring et al. 2013). White-sided dolphins were also recorded between Florida and Nova Scotia during 2012 aerial and vessel surveys between March and May (208 individuals), and September to November (278 individuals) (NEFSC and SEFSC 2012).

4.20 Risso's Dolphin

Risso's dolphins occur in U.S. Atlantic waters year-round typically along the continental shelf edge (Waring et al. 2013); they are considered regular inhabitants of the survey area (Table 4-1). Those occurring in the western Atlantic are considered to be from the Western North Atlantic stock that ranges from the Caribbean north to Newfoundland and Labrador (Waring et al. 2013; Jefferson et al. 2014). During spring, summer and autumn, they occur from Cape Hatteras, North Carolina north to Georges Bank; during winter, they associate with slope waters within the MAB (Waring et al. 2013).

The total number of Risso's dolphins in this stock is unknown (Waring et al. 2013). The best available estimate for this species is presented in Table 4-1.

Risso's dolphins were recorded both acoustically and visually during vessel and aerial surveys off Jacksonville, Florida, between January 2009 and January 2012, Cape Hatteras between May 2008 and May 2012, and Onslow Bay between June 2007 and May 2012; however, no abundance estimates were calculated (DoN 2013). Risso's dolphins have been regularly detected acoustically in HARP recordings offshore of Jacksonville, Florida, and Onslow Bay and Cape Hatteras, North Carolina (Hodge 2011; Debich et al. 2013, 2014).

4.21 Common Bottlenose Dolphin

The common bottlenose dolphin inhabits the survey area year-round based on the frequency and regularity of reported sightings in U.S. Atlantic waters (Table 4-1). Populations in the western North Atlantic comprise a complicated structure of 18 different stocks (Waring et al. 2015; see BOEM 2014a). Bottlenose dolphins are common year-round in U.S. Atlantic waters, with some stocks occupying the same range all year, while some coastal migratory stocks move seasonally along the coast (Waring et al. 2009, 2014). These different stocks can overlap spatially with other distinct groups of bottlenose dolphin, making it difficult to analyze stock structure and annual mortality rates for separate stocks (Torres et al. 2003; Waring et al. 2009, 2014). Bottlenose dolphins occupy a variety of habitats. They can be found on the outer continental shelf and slope, as well as close to shore and in inshore waters, including bays, sounds and estuaries; however, highest densities tend to occur within inner shelf areas (Wells and Scott 1999; Hamazaki 2002; Waring et al. 2014). Because of the location of WesternGeco's survey area (no closer than 30 km to shore) there should be no effect from the project to the Estuarine stocks of bottlenose dolphin, which are considered to be resident in the inshore waters of bays and estuaries (e.g., Gubbins 2002, Odell and Asper 1990).

The total number of bottlenose dolphin in all U.S. Atlantic waters is currently unknown, with the best available overall numbers presented in Table 4-1. However, abundance estimates are available for most of the separate stocks. The Western North Atlantic Offshore stock is estimated at 77,532, derived from the sum of abundance estimates during a 2011 summer survey covering waters from central Florida to the lower Bay of Fundy (Waring et al. 2015). Combined, these surveys offer the most coverage within the offshore stock's range (Waring et al. 2015).

The total abundance estimate for coastal bottlenose dolphin stocks in the western Atlantic is 32,833, with a best abundance estimate available for each coastal stock.

Table 4-2. Abundance estimates of western Atlantic stocks of coastal bottlenose dolphins.

Stock	Abundance Estimate	Source
Western North Atlantic Northern Migratory Coastal Stock	11,548	Summer 2002 aerial survey (Waring et al. 2014).
Western North Atlantic Southern Migratory Coastal Stock	9,173	Summer 2002 aerial survey (Waring et al. 2014).
Western North Atlantic South Carolina/Georgia Coastal Stock	4,377	Average of the abundance estimates from the summer 2002 and summer 2004 aerial surveys (Waring et al. 2014)
Western North Atlantic Northern Florida Coastal Stock	1,219	Average of the abundance estimates from the summer 2002 and summer 2004 aerial surveys (Waring et al. 2014)
Western North Atlantic Central Florida Coastal Stock	4,895	Average of the abundance estimates from the summer 2002 and summer 2004 aerial surveys (Waring et al. 2014).

There is no accurate total abundance estimate for the estuarine and inland water stocks. The best abundance estimate for the Northern North Carolina Estuarine System Stock is

950, calculated from an average of abundance estimates from a 2006 photo-ID mark-recapture survey (Waring et al. 2014). The best abundance estimate for the Southern North Carolina Estuarine System Stock is 188; however, this is an underestimate as estuarine waters are excluded (Waring et al. 2014). The Charleston Estuarine System Stock is estimated at 289 individuals (Waring et al. 2014). The best abundance estimate for the Southern Georgia Estuarine System Stock is 194 (Waring et al. 2014) and the central Georgia Estuarine System Stock is 192 (Waring et al. 2015). Insufficient data exist to calculate abundance estimates for the Northern South Carolina Estuarine System, Northern Georgia/Southern South Carolina Estuarine System, Florida Bay, Jacksonville Estuarine System, Indian River Lagoon Estuarine System, and Biscayne Bay Stocks.

Bottlenose dolphins are commonly seen during other surveys and studies in the U.S. Atlantic as well. They were both visually and acoustically detected during a 2007-2012 study of the U.S. Navy OPAREAs off Cape Hatteras, Jacksonville and Onslow Bay (DoN 2013), as well as during a vessel survey during spring and fall 2012 from Florida north to Nova Scotia (NEFSC and SEFSC 2012). Visual detections of bottlenose dolphins were also recorded during a 2008-2009 survey of New Jersey waters (GMI 2010).

Bottlenose dolphins are most common species seen stranded along the Atlantic coast (Waring et al. 2014). An extensive stranding record exists: 1,053 strandings were reported from 1997 to 2008 with strandings peaking in the spring and fall (Byrd et al. 2014). Since July 2013, NMFS has declared an Unusual Mortality Event (UME) for bottlenose dolphins in the Mid-Atlantic region (BOEM 2014a; NOAA 2014b). Strandings of this species have occurred from New York to Florida (BOEM 2014a; Byrd et al. 2014; NOAA 2014b). Based on preliminary data, the mortality event may have been caused by cetacean morbillivirus (NOAA 2014b).

4.22 Pantropical Spotted Dolphin

Pantropical spotted dolphins in the western Atlantic are considered to be part of the Western North Atlantic stock (Waring et al. 2007). They occur in U.S. Atlantic waters year-round, and are typically found in oceanic waters (Waring et al. 2013). They have not been commonly seen in the proposed seismic survey area (CETAP 1982, AMAPPS 2010, 2011, 2012, 2013, 2014, Roberts et al. 2015).

The NOAA/NMFS Stock Assessment Report (SAR) reports an abundance estimate of 4,439 pantropical spotted dolphins which is the combined estimate from two 2004 western U.S. Atlantic surveys (Waring et al. 2007) (Table 4-1). The first vessel survey covered from north of Maryland to the Bay of Fundy, and resulted in an estimated abundance of 0 (Waring et al. 2007). The second vessel survey covered the U.S. outer continental shelf and continental slope between Florida and Maryland; this resulted in an estimated abundance of 4,439, with the majority of sightings in the waters north of Cape Hatteras, North Carolina along the shelf break (Waring et al. 2007).

Although pantropical spotted dolphins are uncommon during surveys, recent evidence supports their presence in the western Atlantic. During a summer 2011 vessel and aerial survey north of North Carolina, 1 pantropical spotted dolphin was recorded (Palka 2012). Multiple sightings occurred in the VACAPES Range Complex during a survey in August 2010

(375 individuals approximately) (DoN 2013). Stranding records between 1997 and 2008 included 3 confirmed strandings of pantropical spotted dolphins in South Carolina and North Carolina (Byrd et al. 2014). Reports from 1992 to 2004 between Florida and Cape Cod confirmed 3 pantropical spotted dolphin interactions with pelagic long-line fishing gear (Garrison 2007).

4.23 Atlantic Spotted Dolphin

The Atlantic spotted dolphin is considered a regular year-round inhabitant of the survey area based on its reported presence in the U.S. Atlantic (Table 4-1). Those in the western Atlantic are considered to belong to the Western North Atlantic stock (Waring et al. 2013). Atlantic spotted dolphins occur in U.S. Atlantic waters year-round, ranging from southern New England south through the Caribbean and GoM to Venezuela (Waring et al. 2013). This species typically inhabits inshore waters and along the continental shelf edge and slope (Waring et al. 2013). Sightings are concentrated in slope waters north of Cape Hatteras; south of this area, sightings tend to occur in shelf waters extending into deeper slope and offshore waters (Waring et al. 2013).

Atlantic spotted dolphins are common in U.S. Atlantic waters, and are regularly observed during surveys. They were recorded in aerial and vessel surveys between 2007 and 2012 in 3 U.S. Navy operating areas, detected both visually and acoustically off Onslow Bay and Jacksonville, and detected visually off Cape Hatteras (DoN 2013). An abundance estimate of 4,200 Atlantic spotted dolphins was calculated for Onslow Bay based on these studies. Abundance was not calculated for Jacksonville or Cape Hatteras. Atlantic spotted dolphins were also recorded during aerial, visual and acoustic surveys conducted during 2012 in the U.S. Atlantic waters (NEFSC and SEFSC 2012).

The total number of Atlantic spotted dolphins is unknown, but a recent stock abundance estimate is 26,798, based on a 2011 vessel survey of U.S. Atlantic waters (Palka 2012; Waring et al. 2013). The best available abundances for this species are presented in Table 4-1. Prior to 1998, abundance estimates for the Atlantic spotted dolphin were combined with pantropical spotted dolphin, as these species are difficult to differentiate at sea.

4.24 Spinner Dolphin

Spinner dolphins are considered rare in the U.S. Atlantic EEZ and thus the survey area (Table 4-1). Those in the western Atlantic are considered to be part of the Western North Atlantic stock (Waring et al. 2007), for which distribution is poorly known. Spinner dolphins inhabit offshore deep waters (Waring et al. 2007). Seasonal distribution of spinner dolphins in the Western North Atlantic stock is unknown, and there are insufficient data to obtain an abundance estimate for this stock (Waring et al. 2007). They are not commonly seen during surveys in the AOI (BOEM 2014a). During an aerial survey off Cape Hatteras between May 2008 and May 2012, one sighting of 70 spinner dolphins was recorded (DoN 2013). Several spinner dolphins have also been recorded in stranding records, with 3 reported strandings in North and South Carolina between 1997 and 2008 (Byrd et al. 2014).

4.25 Clymene Dolphin

Clymene dolphins are considered rare in the U.S. Atlantic EEZ (Waring et al. 2007) and thus the survey area (Table 4-1). In the western Atlantic they considered to be part of the Western North Atlantic stock where they inhabit coastal and oceanic waters along the continental shelf edge and slope (Waring et al. 2007). Seasonal abundance and distribution of Clymene dolphins in the western Atlantic is unknown, and insufficient data exist to estimate stock abundance (Waring et al. 2007). The only abundance estimate for this stock comes from a 1998 survey between Maryland and Florida when 4 groups were recorded. The resulting estimate of 6,086 dolphins is considered unreliable, as it is over 15 years old (Waring et al. 2007). No subsequent sightings have occurred during U.S. Atlantic marine mammal stock assessment surveys; however, 1 group of 70 was recorded during an aerial survey off Cape Hatteras, North Carolina between May 2011 and May 2012 (DoN 2013). Clymene dolphins have also appeared in stranding records, with 4 strandings reported in North and South Carolina between 1997 and 2008 (Byrd et al. 2014).

4.26 Striped Dolphin

Striped dolphins are considered common in U.S. Atlantic waters and thus the survey area (Table 4-1). Those in the western Atlantic are considered to be part of the Western North Atlantic stock that ranges from Nova Scotia south to Jamaica and into the GoM (Waring et al. 2013). This species occurs year-round along the continental shelf edge from Cape Hatteras to Georges Bank, as well as offshore and along the continental slope in the mid-Atlantic region (Waring et al. 2013).

The estimated stock abundance is 46,882, based on a 2011 survey of U.S. Atlantic waters north of North Carolina to the Bay of Fundy (Waring et al. 2013). During this survey, the majority of sightings were concentrated on the continental shelf edge and slope areas west of Georges Bank (Palka 2012; Waring 2013). During a survey off Cape Hatteras between May 2011 and May 2012, four sightings totaling 885 striped dolphins were recorded (DoN 2013). A survey conducted in spring and fall 2012 between Florida and Nova Scotia resulted in 5 sightings totaling 288 striped dolphins (NEFSC and SEFSC 2012). An overall Atlantic region population is presented in Table 4-1.

4.27 Short-beaked Common Dolphin

Short-beaked common dolphins occur regularly in the U.S. Atlantic and are thus considered regular year-round inhabitants of the survey area (Table 4-11). Those in the western Atlantic are considered to be part of the Western North Atlantic stock (Waring et al. 2013). The species commonly occurs along the continental shelf and slope, particularly north of Cape Hatteras; however, they can be found as far south as Georgia (Waring et al. 2013). Short-beaked common dolphins inhabit U.S. Atlantic waters year-round, ranging from Cape Hatteras north to the Scotian shelf (Waring et al. 2013). From mid-January to May, short-beaked common dolphins occur from Cape Hatteras north to Georges Bank; in mid-summer to autumn, they move north to the Scotian Shelf (Waring et al. 2013).

The SAR reports an abundance estimate of 67,191 from a 2011 aerial and vessel survey from North Carolina north to the Bay of Fundy (Palka 2012; Waring et al. 2013). Short-beaked common dolphins have also been seen commonly during other surveys of the U.S. Atlantic. In U.S. Navy operating areas off Cape Hatteras, Jacksonville and Onslow Bay from 2007 to 2012, common dolphins were recorded visually in Onslow Bay and both visually and acoustically in the Cape Hatteras area (DoN 2013). A survey of the U.S. Atlantic coast between Florida and the Bay of Fundy during spring-fall 2012 encountered 831 short-beaked common dolphins (NEFSC and SEFSC 2012). During an aerial and vessel survey between January 2008 and December 2009, 32 groups of common dolphins were recorded off the coast of New Jersey (GMI 2010). The estimate for the larger North Atlantic region is presented in Table 4-11.

4.28 Fraser's Dolphin

Fraser's dolphins are considered rare in U.S. Atlantic waters (Waring et al. 2007) and thus the survey area (Table 4-1). Those in the western Atlantic are considered to be part of the Western North Atlantic stock, and their distribution is poorly known though they tend to inhabit deeper water (Waring et al. 2007). Seasonal distribution of Fraser's dolphin in the Western North Atlantic stock is unknown, and insufficient data exist to estimate stock abundance. Sightings of Fraser's dolphins are rare during cruises in the AOI. During a 1999 vessel survey of the U.S. Atlantic coast, 1 group of 250 Fraser's dolphins was sighted off the coast of Cape Hatteras (Waring et al. 2011). There were also reported sightings of Fraser's dolphins off Cape Hatteras during aerial surveys between 2008 and 2012 (DoN 2013).

4.29 Harbor Porpoise

The harbor porpoise is considered rare in the survey area based on available data (Table 4-1). Of the 6 species of porpoise, only the harbor porpoise occurs in the Atlantic Ocean (Hohn et al. 2013). Of the 4 discrete subpopulations of harbor porpoise off the eastern Atlantic coast, the Gulf of Maine-Bay of Fundy stock inhabits waters off the U.S. eastern coast and thus the survey area (Waring et al. 2013). Population trends and status of this stock are unknown (Waring et al. 2013).

The small coastal harbor porpoise generally inhabits shallow, coastal waters of the continental shelf but is occasionally seen in deeper waters (Gaskin 1984; Westgate et al. 1998; Jefferson et al. 2008; Waring et al. 2013; BOEM 2014a). During fall and spring, harbor porpoise are widely dispersed from New Jersey north to Maine; however, during winter, they range from New Brunswick, Canada, to North Carolina (Waring et al. 2013; BOEM 2014a). There are 2 harbor porpoise stranding records from Florida during March 1984 and 1985 (Smithsonian strandings database) and 1 in 2003 (NE Regional Office/NMFS strandings and entanglement database) (Palka et al. 1996; Waring et al. 2013; BOEM 2014a). The OBIS-SEAMAP Strategic Environmental Research and Development Program (SERDP) online database (Read et al. 2009) for the proposed project area indicated a density of zero for this species (Table 4-1).

4.30 Pinnipeds

Four species of true seals may occur within the MSA OCS: the gray, harbor, harp, and hooded seals. The normal range of these species is typically north of the WesternGeco proposed survey area. Over the last decade, pinniped sightings and stranding events have increased and been documented in Mid-Atlantic areas, where sightings normally were very few (BOEM 2014a). The influx in sighting and stranding events in the Mid-Atlantic area suggests that the distributions of these seals may be expanding into areas outside of their normal documented ranges (NOAA Northeast Stranding Network, unpublished pinniped stranding records for New Jersey, Delaware, Maryland, and Virginia, 2007-2011, BOEM 2014a).

4.30.1 Harbor Seal

The harbor seal is found in all nearshore waters of the North Atlantic and adjoining seas north of 30ºN (Katona et al. 1993; Waring et al. 2014). Individuals encountered in the AOI are considered to be part of the Western North Atlantic stock. The stock structure is unknown, however, harbor seals found along the eastern coasts of the U.S. and Canada are believed to belong to the same population (Temte et al. 1991; Andersen and Olsen 2010; Waring et al. 2014). They are distributed from eastern Canada to southern New England and New York, with occasional occurrence in the Carolinas (Mansfield 1967; Boulva and McLaren 1979; Katona et al.1993; Gilbert and Guldager 1998; Baird 2001; Desportes et al. 2010; Waring et al. 2014). Dispersed sightings and stranding events have been seen as far south as Florida (NMFS unpublished data). Although primarily coastal, dives to over 500 m (1,640 ft) have been recorded (Jefferson et al. 2008; BOEM 2014a).

Between September and late May, harbor seals occur seasonally along the southern New England to New Jersey coasts (Schneider and Payne 1983; Barlas 1999; Schroeder 2000; deHart 2002; Waring et al. 2014). A northward movement from southern New England to Maine and eastern Canada occurs prior to pupping season, which occurs along Maine from mid-May through June (Richardson 1976; Wilson 1978; Whitman and Payne 1990; Kenney 1994; deHart 2002; Waring et al. 2014). Breeding and pupping within U.S. waters normally takes place north of the New Hampshire/Maine border, but was observed as far south as Cape Cod in the early twentieth century (Temte et al. 1991; Katona et al. 1993; Waring et al. 2014). Pupping has also been recently seen at popular haulout sites off Manomet, Massachusetts (Waring et al. 2014). A general southward movement from the Bay of Fundy to southern New England follows in autumn and early winter (Rosenfeld et al. 1988; Whitman and Payne 1990; Barlas 1999; Jacobs and Terhune 2000; Waring et al. 2014). Within the northern AOI, between Delaware and Virginia, there were 161 harbor seal strandings between 2007 and 2011 (NOAA Northeast Stranding Network, unpublished pinniped stranding records for New Jersey, Delaware, Maryland, and Virginia, 2007-2011; BOEM 2014a).

The estimated population for the Western North Atlantic stock, based on a 2012 survey along the coast of Maine, is 75,834 (Waring et al. 2015). A trend analysis has not been conducted for this stock (Waring et al. 2015).

4.30.2 Harp Seal

The harp seal is found throughout most of the North Atlantic and Arctic Oceans (Ronald and Healey 1981; Lavigne and Kovacs 1988; Waring et al. 2014). The largest harp seal stock, located off eastern Canada, is the Western North Atlantic stock. This stock is composed of 2 breeding herds (the Front herd which breeds off the coast of Newfoundland and Labrador, and the Gulf herd which breeds near the Magdalen Islands, central to the Gulf of St. Lawrence (Sergeant 1965; Lavigne and Kovacs 1988; Waring et al. 2014).

This species is highly migratory (Sergeant 1965; Stenson and Sjare 1997; Waring et al. 2014). Harp seals live primarily in pack ice, but can be found in other habitats during the summer months (BOEM 2014a). They are known to dive to about 370 m (1,200 ft) (Ronald and Healey 1981; Reeves et al. 1992; Lavigne 2002; Jefferson et al. 2008; BOEM 2014a). Over the last few decades, the number of sightings and stranding events along the east coast of the U.S. has been rising (Waring et al. 2014). These occurrences have taken place from Maine to New Jersey (Katona et al. 1993; Rubinstein 1994; Stevick and Fernald 1998; McAlpine 1999; Lacoste and Stenson 2000; Waring et al. 2014), and are considered to be extralimital (Harris et al. 2002, Waring et al. 2014). Harp seal appearance in U.S. waters coincides with the Western North Atlantic stock's most southern point of migration, during January through May (Harris et al. 2002; Waring et al. 2014). In addition, a southern shift in the stock's winter distribution off Newfoundland was seen during the mid-1990s, attributed to abnormal environmental conditions (Lacoste and Stenson 2000; Waring et al. 2014). From 2007-2011, between Delaware and Virginia, there were 180 harp seal strandings (NOAA Northeast Stranding Network, unpublished pinniped stranding records for New Jersey, Delaware, Maryland, and Virginia, 2007-2011, BOEM 2014a).

The stock status in the U.S. Atlantic EEZ is unknown, but the abundance appears to be stable (Waring et al. 2014). The best population estimate, based on a 2012 model, is 7.1 million (Waring et al. 2014). Pup production estimates and models for population size, resulting from a 2012 aerial survey, are currently being analyzed (Waring et al. 2014).

4.30.3 Gray Seal

The gray seals that occur in the AOI are considered to belong to the Western North Atlantic stock, equivalent to the eastern Canada population (Waring et al. 2014). This stock exhibits a year-round range from New York to Labrador, extending seasonally to south of New Jersey between September and May (Waring et al. 2014), however, stranding records as far south as Cape Hatteras have been documented (Davies 1957; Mansfield 1966; Katona et al. 1993; Lesage and Hammill 2001; BOEM 2014a). Although capable of diving to depths of 300 m (984 ft), these animals spend most of their time in coastal waters (Jefferson et al. 2008; BOEM 2014a).

The stock consists of 3 breeding groups in eastern Canada: Sable Island, Gulf of St. Lawrence, and the Nova Scotian coast (Laviguer and Hammill 1993; Waring et al. 2014). Beginning in December 2001, NMFS has monitored the gray seal pup production on Muskeget Island and adjacent sites in Nantucket Sound, as well as Green and Seal Islands off the Maine coast through aerial surveys (Wood et al. 2007; Waring et al. 2014). Gray seals currently have 3 established U.S. pupping colonies: Muskeget Island, Massachusetts, Greeen Island and Seal Island, Maine (Waring et al. 2014). Recently, Matinicus Rock and

Mount Desert Rock, Maine have also been pupping locations for the stock (Waring et al. 2014). White coated pups have stranded on eastern Long Island, however, no pupping colonies have been documented in the area (Waring et al. 2014). Between 2007 and 2011, the gray seal had the highest number of strandings among the 4 seal species that occurred in the northern AOI (BOEM 2014a). Along the coastline between Delaware and Virginia, there were 205 records for the species during the above noted time period (NOAA Northeast Stranding Network, unpublished pinniped stranding records for New Jersey, Delaware, Maryland, and Virginia, 2007-2011; BOEM 2014a).

While the current status of this gray seal stock is unknown, its abundance does appear to be increasing in Canadian and U.S. waters (Waring et al. 2014). The total Canadian gray seal population was estimated to be 331,000 based on modeling (Hammill et al. 2012; Department of Fisheries and Oceans 2013; Waring et al. 2014).

4.30.4 Hooded Seal

The hooded seals occurring in the AOI are considered to belong to the Western North Atlantic stock (Waring et al. 2007. They occur throughout most of the North Atlantic and Arctic Oceans (King 1983; Waring et al. 2007), with a preference for deeper, further offshore waters in comparison to the harp seals (Sergeant 1976; Campbell 1987; Lavigne and Kovacs 1988; Stenson et al. 1996; Waring et al. 2007). Hooded seals are typically encountered in pack ice environments (Waring et al. 2007). They are known to perform foraging dives at depths of about 100-600 m (325-1,950 ft) for 15 min, but dives over 1,000 m (3,280 ft) for up to an hour at a time have been recorded (BOEM 2014a). This species is highly migratory and can be seen as far south as Puerto Rico (Mignucci-Giannoni and Odell 2001; BOEM 2014a).

Between January and May, hooded seals occur in New England waters, with increased numbers spending the summer and autumn months off the southeast U.S. coast (Maine to Florida) and in the Caribbean (McAlpine 1999; Harris et al. 2001; Mignucci-Giannoni and Odell 2001; Waring et al. 2007). It is unknown which stock these seals come from, however, it is known that during the spring months, the Western North Atlantic stock is at its southernmost point of migration in the Gulf of St. Lawrence (Waring et al. 2007). The seals stay on the Newfoundland continental shelf during the winter/spring (Stenson et al. 1996; Waring et al. 2007), with breeding occurring in March. This stock pups in 3 separate areas, all off the eastern Canadian coast (Waring et al. 2007). The largest herd, the Front herd, breeds off the coast of Newfoundland and Labrador (Waring et al. 2007). The Gulf herd breeds in the Gulf of St. Lawrence, and the third herd occurs in the Davis Strait (Waring et al. 2007). Molting occurs between late June and August in the Denmark Strait (King 1983; International Council for the Exploration of the Sea 1995; Waring et al. 2007). There were only 5 documented stranding events of the species within the northern AOI from Delaware and Virginia between 2007 and 2011 (NOAA Northeast Stranding Network, unpublished pinniped stranding records for New Jersey, Delaware, Maryland, and Virginia, 2007-2011; BOEM 2014a).

The status of hooded seals in the U.S. Atlantic EEZ is unknown, but the stock appears to be exhibiting an increase in abundance (Waring et al. 2007). The best estimate of abundance for the Western North Atlantic hooded seals is 592,100 (Waring et al. 2007).

5 Type of Incidental Take Authorization Requested

The type of incidental taking authorization that is being requested (i.e., takes by harassment only; takes by harassment, injury, and/or death) and the method of incidental taking.

WesternGeco requests an IHA pursuant to Section 101(a) (5) (D) of the MMPA for incidental non-lethal "take" by harassment of small numbers of cetaceans during its planned seismic surveys in the MCA OCS during 2016-2017. The type of incidental "take" most likely to occur is that associated with Level B harassment considered to be exposure to pulsed noise received sound levels (RSLs) of ≥ 160 dB (rms) produced by the seismic profiling survey equipment. There is also the potential for Level A harassment or injury (that does not result in mortality), though this is not expected to occur because of mitigation and monitoring measures. NMFS has historically defined this as RSLs ≥ 180 dB (rms) for cetaceans and ≥ 190 dB (rms) for pinnipeds. However, more recently, Southall et al. (2007) defines criteria for Level A harassment that incorporates more variables and cumulative sound exposure; the latter is considered the best available science on the subject. NOAA published draft acoustic guidelines in July 2015 based on information from Southall et al. (2007) and other sources (80 FR 45642). The MMPA defines "harassment" as: "Any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stocks in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

Although Level B harassment is expected to occur during the proposed seismic operations, Level A exposure is considered unlikely to occur as a result of the proposed activity given the following considerations (discussed further in Sections 7 and 11):

- Proposed implementation of monitoring and mitigation measures is designed to reduce and minimize potential negative impacts to marine mammals (including ramp up and shutdown of the seismic source and operation of a smaller mitigation source to alert animals);
- Empirical data indicate that some animals move away from seismic sounds (see Section 7);
- It is considered likely, given sufficient notice through relatively slow ship speed (~4-5 kt during seismic operations), that marine mammals will move away from a noise source that is annoying prior to its becoming potentially injurious;
- Alternate areas of similar habitat value are available for marine mammals to temporarily vacate the survey area during the operation of the seismic source to avoid acoustic harassment;
- The potential for temporary and particularly permanent hearing impairment close to the seismic source is estimated to be low and will likely be avoided through implementation of required monitoring and mitigation measures (including ramp up and shutdown measures);
- The ability of trained PSOs to detect marine mammals is higher at closer proximity to the vessel.

With implementation of the monitoring and mitigation procedures described in this IHA request, potential impacts to marine mammals are expected to be temporary, with no long-term adverse impacts to populations based on available studies (summarized in Section 7). Although exposures to seismic sounds above the current NMFS' recommended 180 dB (rms) Level A threshold have occurred during PSO monitoring programs (e.g., LGL 2013, United States Geological Survey [USGS] 2014), no associated serious injuries or mortalities have been documented and/or conclusively linked causally from exposure to seismic sounds. Available data suggest that the sound sources in the proposed survey are unlikely to cause direct serious injury or mortality of marine mammals, as that would require an animal to be very close to the operating seismic source (Richardson et al. 1995; Southall et al. 2007).

Studies have shown that hearing threshold changes can occur in odontocetes and pinnipeds when exposed to short tones and moderate intensity sounds for extended periods; however, there is little or no direct evidence for biologically significant effects of seismic surveys on marine mammals (though there is a lack of studies that test for effects at this level) (Gordon et al. 2004). No direct mortality or injury from seismic surveys is described in Gordon et al. (2004)'s overview of the literature to date on the subject of the effects of seismic surveys on marine mammals. Ketten (2002) states that studies of TTS in marine mammals have indicated that hearing frequency is an important factor and that PTS has not been directly studied. Ketten (2002) goes on to say that an important aspect of PTS in general is signal-rise time and duration of peak pressure; if exposure is short, marine mammals usually recover their hearing. The mitigation measures that involve ramp-up and shutdown procedures, a moving sound source towed by the transiting vessel, as well as the likelihood of marine mammals moving away from the sound source as it approaches or ramps up, reduce the probability of inducing PTS (or TTS) during the proposed survey.

Notably, project activities proposed within this IHA application were included in the BOEM PEIS's impact analyses of multiple, multi-year seismic operations proposed for the MSA OCS (BOEM 2014a). BOEM (2014a) concluded that impacts to marine mammals would be moderate based on conservative estimates of exposures that BOEM acknowledged were higher than probable actual take. The BOEM document included complex computer modeling of estimated cumulative sound exposures of marine mammals in the MSA OCS to a 5,400 in^3 seismic array. Resulting analyses indicated that mostly none to few exposures to minimum sound levels considered to cause potential Level A harassment could occur when applying more recent criteria based on Southall et al. (2007) (BOEM 2014a). The latter modeling effort represented over 8 times more linear seismic trackline effort with a 5,400 in^3 seismic array during 2015 (217,850 km) than proposed trackline in this application (26,641 km) (summarized in Appendix C). (Note the estimate of which year this distance would be covered in is not relevant; estimates for 2015 in the BOEM PEIS can be compared to distances covered in any given year of seismic surveys). Based on available data, behavioral disturbance reactions and thus the overall number of "incidental" exposures that could occur are expected to vary by the species of cetacean or pinniped, the animal's behavior at the time of the sound reception, and distance and RL of the sound (see Section 7).

6 Numbers of Marine Mammals that May Be Taken

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in Section 5, and the number of times such takings by each type of taking are likely to occur.

This section addresses the numbers of marine mammals that may be incidentally "taken" by Level B harassment via exposure to pulsed seismic sounds ≥160 dB re1µPa (rms) associated with the proposed 2D seismic project. The terminology "incidental take" comes from Section 101(a) (5) (A-D) of the MMPA, as amended (16 U.S.C. 1371(a) (5)). This section of the MMPA identifies a means and procedures to, upon request, allow the incidental, but not intentional, taking (exposing) of a "small number" of marine mammals by U.S. citizens conducting specific activity (other than commercial fishing) within a specific geographical area. Per the 1994 MMPA amendments, "harassment" is defined as, "any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild" (termed Level A harassment); "or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild" (termed Level B harassment).

During the last approximately 10 years, NMFS has been applying guidelines and criteria for take based on the level of exposure of marine mammals to impulsive anthropogenic sounds that might cause injury (Level A take) or behavioral disturbance (Level B take) (66 FR 9291; NMFS 2005a). These criteria have been based on the rms sound pressure metric. However, this approach has since received criticism (e.g., Madsen 2005, Southall et al. 2007). Thus, NMFS is currently preparing to modify these criteria by applying the SEL sound unit. For example, in December 2013, NMFS issued associated proposed sound exposure guidelines (NOAA 2013b, 2014a) for PTS and TTS using dB SEL_{cum} units in conjunction with dB_{peak} units as dual acoustic thresholds (i.e., use whichever is exceeded first) rather than the currently recommended rms sound units (no interim criteria have been identified for Level B take, i.e., sound exposure associated with changes in marine mammal behavior). These proposed thresholds are different for low-frequency, mid-frequency, and high-frequency hearing cetaceans, and for phocids and otariids including whether they are in water or air (i.e., hauled out) (NOAA 2013b). Note that for potential PTS onset (which is proposed for use in evaluating Level A harassment), the lowest dB_{peak} threshold level in the proposed guidelines is 201 dB_{peak} for impulsive sounds for high-frequency cetaceans, followed by 230 dB_{peak} for low-frequency and mid-frequency cetaceans and 235 dB_{peak} for pinnipeds (not 180 dB or 190 dB [rms])(NOAA 2013b, 2014a). NMFS' interim sound exposure guidelines are based in part on Southall et al.'s (2007) recommendation that for transient sounds, the amount of received energy measured in SEL units can be a more appropriate sound unit to assess potential adverse auditory effects (e.g., PTS and TTS—see Section 7.2.1) of noise exposure on marine mammals. The latter evaluation was the summed result of meetings among a panel of marine mammal experts (Southall et al. 2007).

As of mid-July 2015, the NOAA draft guidelines for marine mammal exposure to anthropogenic sound had not been finalized (NOAA 2013b, 2014a). However, the Southall et al. (2007) criteria have been acknowledged as the best available science, which is why they are being applied to new guidelines. Notably, for the BOEM Atlantic PEIS (BOEM 2014a), applying the criteria proposed by Southall et al. (2007), which is very similar to the criteria proposed in the NOAA draft guidelines, resulted in considerably fewer estimated Level A exposures to seismic noise than the current NMFS' recommended rms criteria. (BOEM modeled both the current rms and proposed SEL exposure criteria to estimate potential Level A takes via exposure to seismic sounds [BOEM 2014a].)

The general approach and basis for estimating the number of marine mammals that might be taken by harassment during WesternGeco's proposed seismic activity in the Mid- and South Atlantic planning areas are described in Section 6.2. This general approach is similar to that used for the recent NSF-funded L-DEO IHA in the North Atlantic planning area (LGL 2014a) and many other past and recent IHAs (e.g., Smultea et al. 2013, Simpson et al. 2014), and is referred to as the "historical" approach in the BOEM PEIS (BOEM 2014a). In addition, an approach for estimating potential Level A exposures, assuming no mitigation, relative to the Southall et al. (2007)-based method applied in the BOEM PEIS (BOEM 2014a) is reported in Appendix C, Table C 2; however, no Level A exposures are actually expected because of mitigation and monitoring (see Section 11).

The method of estimating marine mammal density in this application applies a different set of density estimates than previously applied in the BOEM PEIS (BOEM 2014a) and other recent IHA applications for the Atlantic (e.g., USGS 2014). WesternGeco has used the most recently available density data from the Cetacean Density and Distribution Mapping Working Group (CetMap) (Roberts et al. 2015) to estimate exposures. These data are more current than the Navy OPAREA Density Estimates (NODE) data from OBIS-SEAMAP used in the BOEM PEIS (BOEM 2014a). However, it should be noted that the associated documentation for CetMap is not complete or published as of the date of this application submission. Also, the newest NMFS survey data from the Atlantic Marine Assessment Program for Protected Species (AMAPPS) surveys (2010-2014) are not included in the CetMap density estimates (Roberts et al. 2015). When sighting data were considered sufficient by Roberts et al. (2015), they used environmental parameters in modeling the potential for species to occur in an area. As has been found in the Pacific, in some cases, predicted habitats are not occupied at expected densities when such models are ground-truthed with field observations, though sometimes they are (e.g., Becker et al. 2010). For example, models predicted use of habitat by false killer whales near the Northwestern Hawaiian Islands that was later found to be occupied by false killer whales, but similar models did not accurately predict surface densities of *Kogia* spp., Risso's dolphins, killer whales, and beaked whales (Becker et al. 2010). There are many years of surveys covering over 1 million km of tracklines in the Western North Atlantic EEZ, including the proposed seismic survey area (see CETAP 1982, Waring et al. 2014, AMAPPS 2010, 2011, 2012, 2013, 2014, Roberts et al. 2015). Thus, there is no strong reason to believe that animals occur commonly in areas with acceptable habitat but no or few sightings.

Part of the difficulty in cases in which CetMap (Roberts et al. 2015) assumes a small density estimate across an area where a species has never been or is very rarely seen, is that it can result in the model predicting more exposures than are truly likely to occur when estimating potential exposures over a very large area. For example, Becker et al. (2012) states that models in the Pacific were not developed for species with a small number of sightings (<15). However, models in CetMap are sometimes based on as few as 2 sightings (Roberts et al. 2015). Forney (2000) cautions that results of predictive density and abundance modeling come with many caveats.

The basis for estimating the number of potential exposures of marine mammals relative to proposed project seismic operations is presented below. Appendix C provides further details on how exposures were modeled and estimated.

6.1 Basis for Estimating Numbers of Marine Mammals that Might be "Taken by Harassment"

The most recent densities available for the survey area were used as the basis for estimating numbers of marine mammals that might be 'taken by harassment" during WesternGeco's seismic program described in this application. For many marine mammal species the most recent density information was recently made available in the CetMap dataset. CetMap is based on aerial and vessel-based surveys spanning the period 1992-2014 in the U.S. Atlantic EEZ (Roberts et al. 2015). However, there are aspects of the CetMap density data that limit its applicability to estimating marine mammal exposures numbers in the WesternGeco seismic survey area. These limitations are related primarily to the following:

1. The small numbers of sightings for some species despite thousands of km of survey effort,
2. A modeling approach that extrapolates and assumes some species' occurrence and density into areas where they have never been or were rarely documented based on habitat features,
3. In some cases, uniform density models spread densities of species with small sample sizes across large areas of the EEZ without regard to habitat, and
4. AMAPPS vessel and aerial surveys from 2010-2014 are not included.

Thus, as described below in Section 6.3, for some species we have used alternative approaches to CetMap-based density estimates.

The density estimates in CetMap replace the density estimates provided in OBIS-SEAMAP prepared by the U.S. Navy (Navy), known as the NODE database (DoN 2007, 2014). CetMap includes data collected during aerial and ship-based surveys (Table 6-2) conducted during all months of the year spanning the U.S. Atlantic EEZ (see Roberts et al. 2015 for further details). These surveys comprise a total of 1,039,000 km of survey trackline and 9,194 hr of observation effort and are identified below. A total of 490,000 km of effort was in approximately the WesternGeco proposed seismic survey area (Table 6-2). (Note that the AMAPPS surveys from 2010-2014 are not included in this dataset):

- Northeast Fisheries Science Center (NEFSC) Aerial Surveys
- NEFSC NARWSS Harbor Porpoise Survey
- NEFSC North Atlantic Right Whale Sighting Survey
- NEFSC Shipboard Surveys
- New Jersey Department of Environmental Protection (NJDEP) Aerial Surveys
- NJDEP Shipboard Surveys

- Southeast Fisheries Science Center (SEFSC) Atlantic Shipboard Surveys
- SEFSC Mid-Atlantic *Tursiops* Aerial Surveys
- SEFSC Southeast Cetacean Aerial Surveys
- University of North Carolina Wilmington (UNCW) Cape Hatteras Navy Surveys
- UNCW Early Marine Mammal Surveys
- UNCW Jacksonville Navy Surveys
- UNCW Onslow Navy Surveys
- UNCW Right Whale Surveys
- Virginia Aquarium Aerial Surveys

Densities and abundances of marine mammals are traditionally estimated by applying the Distance Sampling approach based on Line Transect Theory (Buckland et al. 2001). A minimum sample size of 60-80 sightings is recommended to provide reasonably robust estimates of density and abundance to fit the mathematical detection function required for this estimation; smaller sample sizes result in higher variance and thus less confidence and less accurate estimates (Buckland et al. 2001). For the CetMap data, in cases with fewer than the minimum 60-80 sightings recommended by Buckland et al. (2001), densities were estimated by Roberts et al. (2015) by pooling surveys and using proxy species to evaluate detection functions. When Roberts et al. (2015) considered there were enough data, they applied 3 main models (climatological, contemporaneous, and climatological same segments) to estimate densities that were mapped in 10 km X 10 km grid squares throughout the EEZ. These models considered habitat parameters as well as sighting data. If Roberts et al. (2015) determined there were not enough data for these modeling approaches, uniform density models, which involved spreading uniform densities across areas of the EEZ, were applied. (See Roberts et al. [2015] for more detailed information regarding CetMap density modeling by species.) Roberts et al. (2015) also recognized that estimating densities across an area implies an abundance that is the product of the area and the densities. Roberts et al. (2015) evaluated abundance estimates under different circumstances (such as season and model).

In addition to density, it is important to know the abundance of marine mammal species to estimate the numbers of individuals that may be exposed to WesternGeco's proposed seismic program sounds. In some cases, regional population estimates are more meaningful for evaluating potential population level impacts of human activities. CetMap abundance estimates made by Roberts et al. (2015) differ from the abundance estimates provided in the NMFS SARs (Waring et al. 2014). However, this does not necessarily mean one estimate is better than the other. Rather, it should be noted that density estimates in CetMap are not tied in any way to the population estimates in the SARs because SAR estimates came from different (or different combinations of) survey datasets than CetMap densities. The abundance estimate for a U.S. stock in the SAR is typically limited to U.S. jurisdiction, which includes waters extending 200 nm from shore (U.S. MMPA 1972). However, in some cases, larger regional abundance estimates have been made and published, allowing comparison with population sizes that include the range of the population outside of the U.S. EEZ (e.g., International Whaling Commission [IWC] 2013). It can be hard to determine the actual boundaries of interbreeding populations of marine mammals. In some cases (e.g., bottlenose dolphins), data are available that has caused NMFS to split species into multiple stocks within the U.S. EEZ (Waring et al. 2014). Overall, high seas cetaceans are unlikely to follow the U.S. EEZ boundary, so the quality of the data (including number of sightings and how much of the range of the stock is included in the surveys) is an important factor in evaluating whether or not CetMap abundance estimates are appropriate to apply to comparisons with exposure estimates. (More specific evaluation of abundance estimates is provided in Section 6.4.)

To estimate numbers of exposures for areas within the WesternGeco project area where no marine mammal survey effort has been conducted (i.e., nearly all the area outside of the EEZ), an evaluation was made of whether sightings of the species have occurred near or past the EEZ border. In cases of sightings near or past the EEZ border, the closest polygon grid with density data available was extrapolated to adjacent grids to estimate exposures outside the EEZ.

For some species, CetMap provided separate density estimates for each month. For the latter cases, we calculated exposure estimates for each month and took the mean of these values. Seasonal data were not separated because WesternGeco's seismic activities are proposed to occur year-round. The exception to this is that right whale densities were limited to May – October because the area of main concentration of right whales during November – April will not receive any sound levels of 160 dB (rms) because WesternGeco will specifically avoid right whale seasonal management areas during this season (See Section 11 for further details).

Similar limitations were likely associated with the CetMap density estimates as those described for density estimates used in the BOEM PEIS (p. E-26 to E-27, BOEM 2014a). For example, for many species, like the SERDP density estimates, CetMap density estimates are based on a small number of sightings extrapolated across a large area. As result, such estimates are associated with a relatively large standard deviation and degree of error range. To account for this in our modeling, some extremely rare species (< 4 sightings in the CetMap dataset in the proposed seismic area) were considered to have an almost zero probability of encounter. For the latter species, a mean group size obtained from a literature review was used to estimate exposures to account for the small possibility that 1 group could be within the 160 dB (rms) zone. In cases in which the species was seen > 4 times but less than the Buckland et al. (2001) recommended 60-80 times in the proposed seismic survey area, an alternative approach was used. This involved using Line Transect Theory to estimate the density of the species within the 160 dB ensonification zone of the proposed seismic survey and includes sightings from AMAPPS surveys, which were not included in CetMap density analyses (See Section 6.2 through 6.4 for details).

Marine mammal densities from Read et al. (2009) (OBIS-SEAMAP) were used to estimate exposures for the Atlantic BOEM PEIS (BOEM 2014a) and the recent L-DEO IHA in the Atlantic (LGL 2014a). The densities and approach used herein are believed to be the best available at this time. The basis and assumptions for using the applied densities are described briefly below, with further detail in Appendix C.

6.2 Exposure Calculation Methods Using CetMap

The approach used to calculate the estimated number of individuals of each marine mammal species potentially exposed to RLs of pulsed WesternGeco project seismic source sounds ≥ 160 dB re 1 µPa (rms) is described below. It is assumed that marine mammals exposed to seismic source sounds ≥ 160 dB might change their behavior sufficiently to be considered "taken" by Level B harassment. Note that as shown in Table 6-5, no exposures of pinnipeds or white-beaked dolphins are expected to occur as a result of proposed seismic operations given their known distributions, similar to the BOEM PEIS (BOEM 2014a) and other Atlantic IHAs (e.g., USGS 2014). See Appendix C for exposure estimates based on the "Southall Level A" cumulative sound exposure criteria applied in the BOEM PEIS (BOEM 2014a).

The following 4 species were evaluated using CetMap data for which there was only 1 density estimate available for the full year (i.e., seasonal or monthly estimates were not available) (see Section 6.3 for other species and reasons for using alternative evaluation methods):

1. Atlantic spotted dolphin
2. Pilot whale
3. Striped dolphin
4. Beaked whale

For the following 5 species, there were 12 individual months of density estimates in CetMap that were used:

1. Bottlenose dolphin
2. Humpback whale
3. Risso's dolphin
4. Short-beaked common dolphin
5. Sperm whale

There are 12 months of maps available for the northern right whale as well, but as WesternGeco will avoid the area considered to be of highest density from 1 November – 30 April (the Seasonal Management Area), only densities from May - October were used to estimate exposures.

Exposure calculations were done as follows (see Appendix C for further details and explanations):

1. The area of water (in km^2) ensonified to ≥ 160 dB re 1 μPa (rms) around the operating seismic source array on seismic lines, 6 km run-outs, and 8 km ramp-ups and run-ins was calculated. It was assumed for the purposes of this estimation that WesternGeco's full 5,085 in^3 seismic source array would be used during all seismic lines and during the 5 km run-outs associated with turns between seismic lines and the 3 km ramp-ups and run-ins (see Section 1). (Note, however, that the proposed DZ and EZ for mitigation are based on a larger 5,400 in^3 array as described in Section 1.4). Further, where it was estimated that turns/transits would take ≤ 3 hr, it was assumed the 105 in^3 mitigation seismic source was operating. Where it was estimated that turns/transits would take ≥ 3 hr, it was assumed that no seismic sound source was operating between the run-out and ramp-up/run-in for lines.
2. Ensonified waters were calculated as follows for the total 27,331 km of trackline, run-out, and run-in/ramp-up (when it was assumed for modeling purposes that the seismic source was operating at full power). A buffer was applied on both sides of the planned survey tracklines, run-outs, and ramp-up/run-ins (see #1) equivalent to the following (see Section 1.4 for more details about sound propagation modeling and Appendix C, Tables C 1 and C 2 for details regarding how radii were calculated):

   a. A distance of 8,473 m for water depths ≤ 880 m (representing the mean $R_{95\%}$ 160 dB re 1 μPa [rms] isopleth for scenarios at ≤ 880 m depth for the 5,400 in^3 array in BOEM 2014a)
   b. A distance of 6,838 m for depths between 880 m and 2,560 m (representing the mean $R_{95\%}$ of the 160 dB [rms] isopleth for all 21 scenarios for the 5,400 in^3 array in BOEM 2014a because there were no scenarios modeled at these specific depths)
   c. A distance of 5,040 m for depths ≥ 2,560 m (representing the mean $R_{95\%}$ of the 160 dB [rms] isopleth for scenarios at depths ≥ 2,560 m for the 5,400 in^3 array in BOEM 2014a).
3. Ensonified waters were calculated as follows for the 985 km of single mitigation seismic source use. A buffer was applied on both sides of the portions of turns and transits during which the mitigation seismic source would be used (see #1) equivalent to the following (see Section 1.4 for more details about sound propagation modeling):
   a. A distance of 1,681 m for depths ≤ 880 m (representing the mean R95% 160 dB re 1 μPa [rms] isopleth for scenarios at ≤ 880 m depth for the 90 in3 array in BOEM 2014a)
   b. A distance of 1,486 m for depths between 880 m and 2,560 m (representing the mean R95% of the 160 dB [rms] isopleth for all 21 scenarios for the 90 in3 array in BOEM 2014a because there were no scenarios modeled at these specific depths)
   c. A distance of 1,271 m for depths ≥ 2,560 m (representing the mean R95% of the 160 dB [rms] isopleth for scenarios at depths ≥ 2,560 m for the 90 in^3 array in BOEM 2014a)
4. For the total estimated 1,059 km of turns/transits during which it is expected all seismic sources will be silent, no radii were applied and a zero exposure estimate was assumed.
5. For species for which there were 12 months of density estimates in CetMap, we calculated the exposure estimates for each month and took the mean of these estimates, as seismic surveys may occur in any month of the year. The exception was right whales, for which the months of May – October were used because areas with largest concentrations of right whales in November – April (Seasonal Management Areas) will be avoided (see Appendix C, Table C 1**Error! Reference source not found.** for breakdown of estimates by month). For species for which there was only 1 density estimate in CetMap, the 1 estimate was used for calculations.
6. The estimated areas (in km2) ensonified to ≥160 dB re 1 μPa (rms) were calculated using Mysticetus System™ (Mysticetus) software. Mysticetus calculated the ensonified geo-polygons for the radii by the total linear distance (km) for the proposed survey lines and turns/transits (including run-out/ramp-up/run-in). Overlapping areas were treated as if they did not overlap (i.e., they were added together as separate polygon areas to account for multiple exposures in the same location), and were thus included in the total area used to estimate exposures. For each 10 km x 10 km grid, Mysticetus then multiplied the overlapping area (in km2) predicted to be ensonified to ≥160 dB re 1 μPa (rms) by the density (from CetMap (Roberts et al. [2015]) of each marine mammal species. This resulted in estimated Level B exposure numbers.
7. Because this is an instantaneous exposure model, it assumes that all individuals in the model are exposed at the same time, with no consideration for movement. As such, overlapping areas constitute areas where individuals in the model are exposed more than once. To account for this, we have provided information in

Table 6-5 regarding the number of individuals modeled to be exposed and the number of total exposures to differentiate these two situations.

8. Because CetMap does not include density estimates outside of the EEZ, exposure estimates for the 877 linear km (3%) of seismic activity outside the EEZ had to be estimated differently. Sighting data from CetMap (Roberts et al. 2015), CETAP (1982), AMAPPS (2010, 2011, 2012, 2013, 2014), and SARs (Waring et al. 2014) were used to evaluate whether a species had been observed offshore close to the EEZ edge. No specific distance was used because it was impossible to determine exact distances from the EEZ edge using these reports. However, for a few species, it was clear that sightings did not occur off the shelf in the proposed seismic survey area. With respect to species evaluated with CetMap data, these species included the following:
    - Humpback whales
    - North Atlantic right whales
9. For those species that did not occur near the EEZ edge (humpback and right whales), we assumed density of zero outside of the EEZ. For the remaining 8 species evaluated using CetMap (Atlantic spotted, bottlenose, Risso's, common, and striped dolphins and pilot, beaked, and sperm whales), because there are simply no data with which to estimate exposures, we extrapolated density from the nearest neighbor grid cell. It should be noted that in mapping these extrapolated densities, the approach caused swaths of higher densities outside the EEZ in some cases without any literature to support the result. For example, we provide maps of the result of nearest neighbor extrapolations for beaked whale species and striped dolphins in Figure 6-1, below. There is evidence to suggest that marine mammals have habitat preferences (e.g., MacLoed and Zuur 2005). Thus, assuming a higher density swath somewhat randomly extending outside the EEZ is likely to be an overestimate, but there are no data for estimating densities outside the EEZ. Many stocks show preference for the shelf and slope (see Roberts et al. 2015), so it is possible that groups outside the EEZ belong to a different breeding population than those evaluated in CetMap. The total number of estimated exposures were reported separately in Table 6-5 for the ensonified areas within and outside of the EEZ.

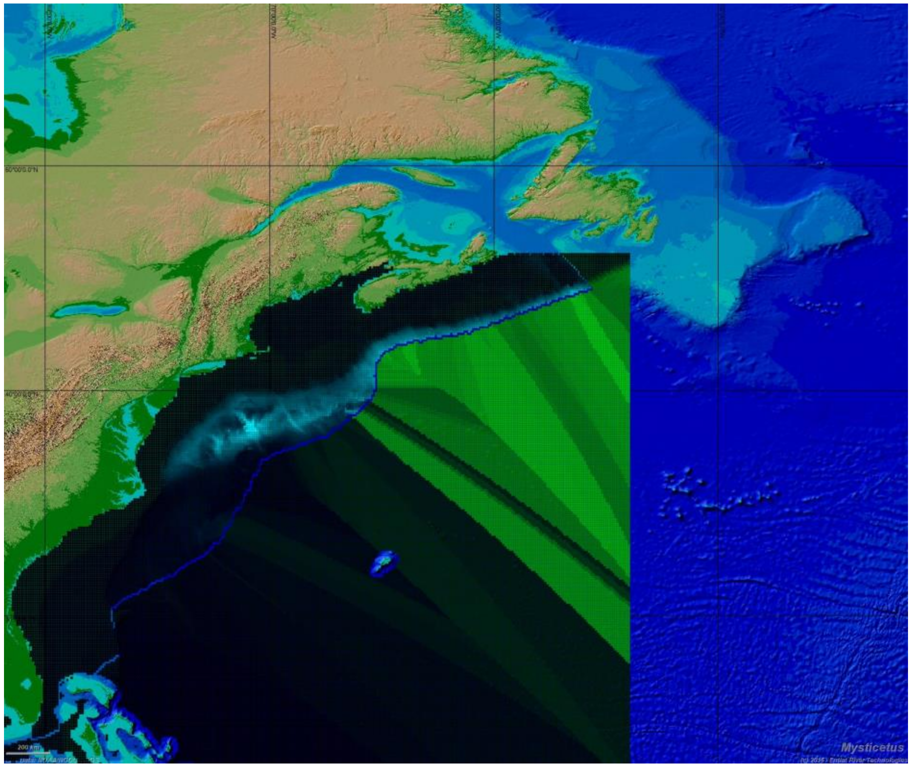

Figure 6-1a

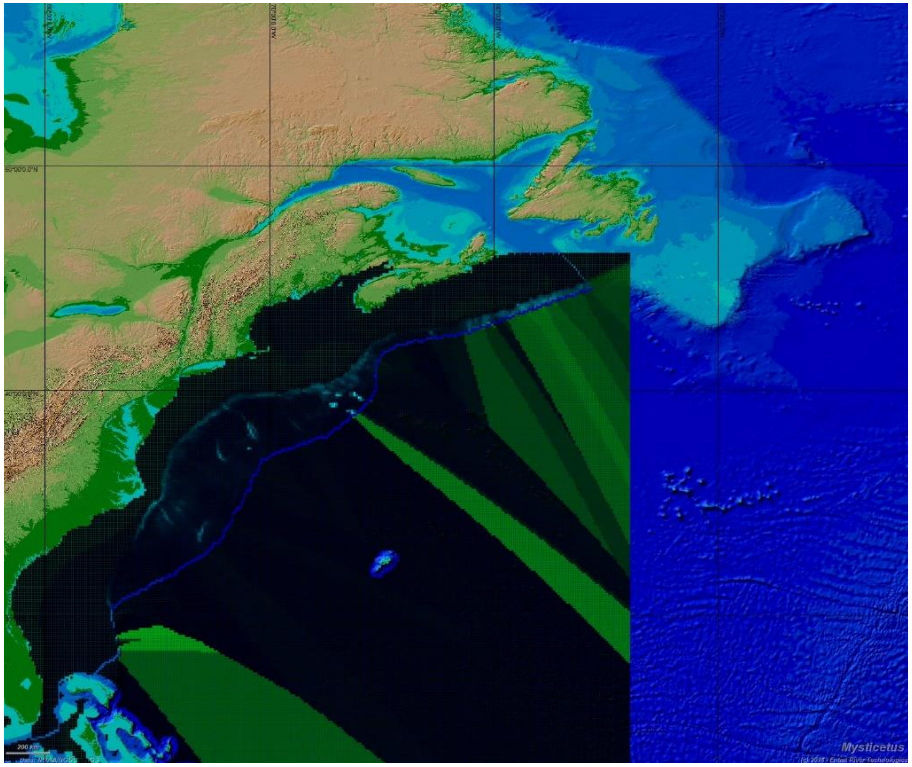

Figure 6-1b

Figure 6-1. a) Map of beaked whale densities extrapolated by nearest neighbor outside EEZ illustrating the higher density swaths inappropriately extended far out to sea. b) Map of striped dolphin densities extrapolated outside EEZ illustrating the higher density swaths extended far out to sea.

10. Roberts et al. (2015) provide abundance estimates based on the data included in CetMap. In some cases, these are appropriate estimates to which to compare exposure estimates that are derived from CetMap data because they account for the effect of density assumptions on abundance. For example, if the abundance estimate in the SAR (Waring 2014) were 1,000, but densities in CetMap resulted in a total of 5,000 individuals (density X area), using CetMap densities assumes there are 5,000 individuals in the model. In some cases, CetMap data are based on more recent data and more sightings than SAR "best" abundance estimates, reducing co-efficient of variation (CV) values and making estimates more precise. Best abundance estimates for comparisons are discussed in Section 6.4.
11. For reference, the geographical area estimated to be ensonified to ≥180 and ≥160 dB re 1 μPa (rms) around proposed project seismic survey lines and turns between lines was calculated and mapped relative to the boundaries of Designated Critical Habitat and Seasonal Management Areas for the North Atlantic Right Whale as identified in the BOEM PEIS (BOEM 2014a) and ROD (BOEM 2014b) (Appendix A, Figure A 1). Proposed mitigation includes operating outside these areas during designated protected periods such that the 160 dB (rms) and 180 dB (rms) seismic isopleths do not overlap this designated seasonally protected boundary (see Sections 11 and 13 for more details on proposed related mitigation).

6.3 Estimated Number of Exposures not Using CetMap

Mean group size was used to identify requested Level B take authorization numbers in cases in which a species is extremely rare and very few sightings have occurred in the proposed seismic survey area based on decades of NMFS surveys. (Note that CetMap includes some of these species, in some cases because they occur more commonly in areas of the Western Atlantic EEZ where WesternGeco is not proposing to conduct surveys, such as north of the WesternGeco survey area). Thus, effectively, these species are so rare as to have an almost zero likelihood of occurring in the proposed WesternGeco seismic survey area. Furthermore, any density estimates made in this area were not based on sufficient data for Roberts et al. (2015) to fit a detection function to that species or evaluate environmental parameters associated with species distribution. Based on available information, it is most likely that if an exposure were to occur for these species, it would be to 1 group during a single encounter. Citations for mean group size calculations are provided in Table 6-5 footnotes. Also see Appendix C, Table C 5 for a breakdown of how mean group sizes were calculated from available data, including AMAPPS (2010, 2011, 2012, 2013, 2014), which were not included in CetMap.

For the 11 extremely rare or absent species, mean group sizes were used as Level B exposure estimates in the proposed WesternGeco seismic survey area. These species had ≤4 sightings in the proposed seismic survey area during surveys from 1992-2014 used in CetMap density modeling (Roberts et al. 2015). The species and respective number of sightings in the proposed seismic survey area (shown in parentheses) that were used in CetMap are shown below.

- Sei whale (4)
- Blue whale (0)
- Pygmy killer whale (CetMap does not estimate densities for this species)
- Northern bottlenose whale (0)

- Fraser's dolphin (2)
- Killer Whale (0)
- Melon-headed whale (4)
- False killer whale (2)
- Spinner dolphin (1)
- Bryde's whale (4)
- Atlantic white-sided dolphins (1)

For line transect analysis, Buckland et al. (2001) recommends at least 60-80 sightings to fit a detection function and provide a moderately robust estimate of density. Detection functions were used by Roberts et al. (2015) in CetMap in density modeling. Some species had ≥4 sightings but did not have the recommended 60-80 sightings, despite 462,000 km of aerial trackline and 28,000 km of shipboard trackline in the general area of the proposed WesternGeco seismic survey (Roberts et al 2015). Although Roberts et al. (2015) chose to use proxy species (other similar species for which there were more sightings) to evaluate the detection function for rarely sighted species, the fact that these species were seen so rarely during so much observation effort suggests that they are not common in the survey area, which includes the proposed seismic survey area.

In the case that a localized activity were being permitted, it may be appropriate to consider such uncommon species and potentially use the densities provided by CetMap to include an exposure estimate in a permit application. Spreading these species across areas where they are never or rarely seen keeps applicants mindful of the possibility that an encounter with these species may occur in those areas. However, for large-scale vessel-based projects, when the probability of encountering the species is extremely low in each grid square considered, the probability of encountering them in all grid squares becomes the product of those probabilities, which will be approaching zero. As such, assuming the species is in all grid squares for modeling magnifies the error associated with the assumption that these species occur continuously throughout large areas of the EEZ where they are rarely or never seen. In order to address this, we have used the fact that density estimates are ultimately based on surveys which act in the same manner as a seismic survey, following prescribed tracklines. Therefore, we can use the information available about how many of a species was seen across a given length of trackline and use an effective strip width (ESW) to evaluate the expected number of animals within the ESW transect area and extrapolate that to the 160 db (rms) ensonification zone. ESW is the distance at which missed sightings made inside the distance is equal to detected sightings outside of it. Estimates can be corrected for animals missed due to observation biases by using a correction factor ($g[0]$), which increases estimates to account for the missed individuals. . Most data used in the CetMap (and AMAPPS) datasets are from aerial surveys (Table 6-1 and Table 6-2). A benefit of this approach is also that AMAPPS data can be included for a more comprehensive analysis.

Because there are some confounding factors associated with combining aerial and vessel surveys with respect to ESW, we have separated vessel and aerial surveys for analysis with different ESW and $g(0)$ values, but we do not apply specific values to each individual survey. The suggestion to split the analysis by survey platform was made by Dr. Thomas A. Jefferson (Marine Mammal Biologist, Clymene Enterprises, pers. comm. July 2015) in reviewing our approach with respect to appropriate use of Line Transect Theory.

Because we are not attempting to estimate accurate abundance or density, but rather make a reasonably conservative estimate, we can use conservative assumptions to estimate a maximum number of individuals of each marine mammal species expected to occur within the 160 dB (rms) zone around the WesternGeco survey vessel using Line Transect Theory. We applied this approach to generate exposure estimates for species with < 60 sightings used in the CetMap analysis of the proposed seismic survey area. AMAPPS (2010, 2011, 2012, 2013, 2014) data were not included in CetMap. However, a total of 123,911 km of trackline was surveyed from aircraft and ships in 2010-2014 as part of AMAPPS, 70,120 km of which were SEFSC surveys that included the proposed seismic survey area (Table 6-1). Thus, we also considered the AMAPPS data in our analysis of exposures.

AMAPPS aerial surveys in the SEFSC extended about 2 degrees north of the proposed WesternGeco seismic survey area to approximately 40 °N in all years and seasons; an exception was winter 2011 when surveys only extended to approximately 36 °N off the coast of northern North Carolina. In certain cases, this includes some sightings north of the proposed seismic survey area. However, given the small number of sightings and an inability to determine trackline distance outside the proposed seismic survey area, these sightings were included in our estimates, causing them to be higher than they would be if those sightings were excluded.

AMAPPS aerial surveys in the SEFSC region extended south to mid-Florida to approximately the same latitude as the proposed seismic surveys; an exception was surveys extending to southern Florida beyond the proposed survey area in spring and fall 2012 and summer 2011, as well as surveys truncated at mid-South Carolina in 2013 and 2014. These AMAPPS SEFSC region aerial surveys extended to approximately the 200 m depth contour (AMAPPS 2010, 2011, 2012, 2013, 2014).

Vessel surveys in the SEFSC region during AMAPPS extended to the edge of the EEZ and slightly beyond. Vessel surveys in 2011 were conducted from approximately 38 °N to 26 °N and around Florida into the Gulf of Mexico (AMAPPS 2011). Vessel surveys in 2013 were conducted from approximately 38 °N to 32 °N (AMAPPS 2013).

NEFSC vessel surveys extended southward far enough to include a small part of the proposed seismic survey area during summer 2011 and 2013 and spring 2014 (reaching approximately 36 °N at their southernmost points). Because it was impossible to determine the trackline distance within the proposed seismic survey area for these surveys, sightings during these surveys were not included in the analysis below.

Surveys included in CetMap by Roberts et al. (2015) (that exclude the AMAPPS dataset) are shown in Table 6-2 and occurred in various areas of the proposed WesternGeco seismic survey area as the names suggest (e.g., Torres et al. 2005, Read et al. 2014, Mallette et al. 2014). Not all survey details are publically available, and more detail regarding which data were used in CetMap is expected to be provided in the ensuing publication which has not yet been released to the public (Jason Roberts pers. comm. July 2015). Given that most of the surveys used in CetMap are relatively location specific, it is reasonable to include sighting information reported in Roberts et al (2015) to evaluate the likelihood that uncommon species would occur within the 160 dB (rms) radius of a seismic survey vessel following tracklines through the Mid- and South-Atlantic planning areas.

To evaluate how many individuals of a species would potentially occur within the 160 dB (rms) isopleth radius (assuming animals do not move away from the vessel prior to experiencing 160 dB [rms] received sound levels), we did as follows (Table 6-4).

1. We calculated the area of transect, based on aerial and vessel surveys respectively, that would be considered to include sightings of all animals present for each species based on ESWs obtained from the literature (Note again that ESW is the distance at which missed sightings made inside the distance is equal to detected sightings outside of it, effectively meaning that the total sightings is equal to the total number of animals within the ESW along the trackline). Equation: 2 X ESW X Transect Line Length = Area of Transect (see Table 6-3 for ESWs and their sources).
2. We calculated the mean density (in groups/area) of each species expected within the area of the transect by taking the number of sightings divided by the area of the transect for aerial and vessel surveys. We then multiplied by the mean group size to get an estimate of individuals/km^2 (i.e. density) (see Table 6-3 for mean group sizes and their sources).
3. We corrected densities using general *g*(0) values for aerial and vessel surveys for each species as published in the literature (see Table 6-3 for *g*(0) values and their sources). We then averaged the vessel and aerial densities for each species, as the WesternGeco survey lines cover areas included in aerial and vessel surveys and as this method accounts for high and low density areas across the survey.
4. We calculated the number of individuals of each species that would potentially occur within the WesternGeco 160 dB radius for the mitigation source and the full power array and added them together to get a total number of individuals potentially exposed. To do this, we multiplied the mean density based on the ESW transect by the area of the WesternGeco 160 db (rms) zone for the mitigation source and the full array respectively and added the results. The area of the 160 dB (rms) zone for the mitigation source was the product of the trackline distance estimated to be at mitigation power (985 km) and the mean 160 dB (rms) radius (1.486 km) X 2. Likewise, the area of the 160 dB (rms) zone for the full array was the product of the trackline distance estimated to be at full array power (27,331 km) and the mean 160 dB (rms) radius (6.838 km) X 2. (See Appendix C for more information on how the mean radii were calculated.)
5. We split the estimated number of potential exposures for each species between inside the EEZ and outside the EEZ by multiplying by the percent of trackline occurring in each area (97% and 3% respectively).
6. We also accounted for overlap in the exposure area in the EEZ by evaluating the number of individuals exposed vs. the total exposures for comparison with abundance estimates. To do this, we multiplied the total exposures in the EEZ by 0.58 to account for the overlap in the ensonification area (see Table 6-5 for further explanation).

Table 6-1. Southeast Fisheries Science Center surveys for marine mammals during AMAPPS program 2010-2014. This excludes the Northeast Fisheries Science Center surveys which were mainly conducted north of 40° N. See AMAPPS (2010, 2011, 2012, 2013, 2014).

Source	Year of Survey(s)	Season	Type&	Trackline (km)	Area	Clymene dolphin	Harbor porpoise	*Kogia* spp.	Pantropical spotted dolphin	Rough-toothed dolphin	Minke whale	Fin whale
AMAPPS 2010	2010	Summer	Aerial	7,944	Cape Canaveral FL to Cape May NJ	0	0	0	0	0	0	4 groups totaling 5 individuals
AMAPPS 2011*	2011	Winter	Aerial	4,934	Cape Canaveral FL to North Carolina	0	0	0	0	1 group of 38	0	2 groups totaling 4 individuals
AMAPPS 2011*	2011	Summer	Aerial	8,665	Ft Pierce FL to Cape May NJ	0	0	0	0	0	0	1 group of 1
AMAPPS 2012	2012	Fall	Aerial	11,775	Southeastern FL to Cape May NJ	0	0	0	0	0	0	6 groups totaling 10 individuals
AMAPPS 2012	2012	Spring	Aerial	11,252	Southeastern FL to Cape May NJ	0	0	0	0	0	5 groups totaling 6 individuals	7 groups totaling 12 individuals
AMAPPS 2013	2013	Winter	Aerial	7,284	Southeastern FL to Cape May NJ	0	8 groups totaling 14 individuals	0	0	0	3 groups totaling 3 individuals	6 groups totaling 7 individuals
AMAPPS 2014	2014	Spring	Aerial	7,778	SC to Cape May NJ	0	2 groups totaling 3 individuals	0	0	0	2 groups totaling 2 individuals	2 groups totaling 4 individuals
Sum for Aerial Surveys				**59,632**		**0 groups**	**10 groups**	**0 groups**	**0 groups**	**1 group**	**10 groups**	**28 groups**

Source	**Year of Survey(s)**	**Season**	**Type[&]**	**Trackline (km)**	**Area**	**Clymene dolphin**	**Harbor porpoise**	***Kogia* spp.**	**Pantropical spotted dolphin**	**Rough-toothed dolphin**	**Minke whale**	**Fin whale**
AMAPPS 2011	2011	Summer	Vessel	5,013	Southeastern FL to MD/DE border including shelf break and slope waters, Blake Plateau, & Gulf of Mexico*	1 group (no group size)	0	17 groups (no group sizes)	3 groups (no group sizes)	1 group (no group size)	0	3 groups (no group sizes)
AMAPPS 2013	2013	Summer	Vessel	5,475	SC to VA	2 groups (no group sizes)	0	47 groups (no group sizes)	3 groups (no group sizes)	3 groups (no group sizes)	0	8 groups (no group sizes)
Sum for Vessel Surveys				**10,488**		**3 groups**	**0 groups**	**64 groups**	**6 groups**	**4 groups**	**0 groups**	**11 groups**
Total for All Surveys				***70,120***		***3 groups***	***10 groups***	***64 groups***	***6 groups***	***5 groups***	***10 groups***	***39 groups***

* The maps in the AMAPPS (2011) report seem to indicate that all the sightings described here were within the Atlantic EEZ and not in the Gulf of Mexico.

[&] Aerial surveys generally extended to about the 200 m depth contour, and vessel surveys typically extended from the 200 m depth contour to or slightly beyond the U.S. EEZ border.

Table 6-2. Surveys for marine mammals in the proposed WesternGeco seismic survey area included in CetMap density estimates 1992-2014. This excludes NEFSC and NJDEP surveys north of the proposed seismic survey area. These values are from Roberts et al (2015) CetMap Supplementary Information.

Survey (based on CetMap supplementary material)	Year(s) of Survey(s)	Type	Trackline (km)	Clymene dolphin	Harbor porpoise	*Kogia* spp.	Pantropical spotted dolphin	Rough-toothed dolphin	Minke whale	Fin whale
SEFSC Mid Atlantic *Tursiops* Aerial Surveys	1995, 2004-2005	Aerial	35,000	1	0	0	2	0	0	6
SEFSC Southeast Cetacean Aerial Surveys	1992, 1995	Aerial	8,000	0	0	0	0	0	0	0
UNCW Cape Hatteras Navy Surveys	2011-2013	Aerial	38,000	3	0	1	0	1	4	5
UNCW Early Marine Mammal Surveys	2002	Aerial	18,000	0	0	0	0	0	0	1
UNCW Jacksonville Navy Surveys	2009-2013	Aerial	132,000	0	0	1	1	5	9	0
UNCW Onslow Navy Surveys	2007-2011	Aerial	98,000	0	0	0	0	3	2	1
UNCW Right Whale Surveys	2005-2008	Aerial	114,000	0	0	0	0	0	0	12
Virginia Aquarium Aerial Surveys	2012-2014	Aerial	19,000	0	0	0	0	0	1	13
Sum for Aerial Surveys			**462,000**	**4**	**0**	**2**	**3**	**9**	**16**	**38**
SEFSC Atlantic Shipboard Surveys	1992-2005	Vessel	28,000	7	0	17	10	2	1	11
Total for All Surveys	***1992-2014***		***490,000***	***11***	***0***	***19***	***13***	***11***	***17***	***49***

Table 6-3. Numbers used to evaluate exposure estimates based on Line-Transect Theory. Refer to Section 6.3 for details in text.

	Aerial Surveys					***Vessel Surveys***					
Species	**Aerial Sightings CetMap**	**Aerial Sightings AMAPPS**	**Total Aerial Sightings**	**ESW aerial (km)**	***g*(0) aerial**	**Vessel sightings AMAPPS**	**Vessel Sightings CetMap**	**Total Vessel Sightings**	**ESW Vessel (km)**	***g*(0) Vessel**	**Mean Group Size**
Clymene dolphin	4	0	4	0.797[M]	0.994[H]	3	7	10	5.025[Z]	0.97[I]	76.1[X]
Harbor porpoise	0	10	10	0.186[L]	0.36[J]	0	0	0	0.375[J]	0.54[J]	2.93[Y]
Kogia spp.*	*2*	0	*2*			64	17	81	1.849[L]	0.35[I]	1.9[Z]
Pantropical spotted dolphin	3	0	3	0.797[M]	0.994[H]	6	10	16	5.025[Z]	0.97[I]	77.5[Z]
Rough toothed dolphin	9	1	10	0.775[M]	0.96[H]	4	2	6	4.016[Z]	0.856[I]	14[Z]
Minke whale	16	10	26	0.369[L]	0.386[H]	0	1	1	1.151[L]	0.70[J]	1.5[V]
Fin whale	38	28	66	0.34[L]	0.442[L]	11	11	22	2.008[L]	0.94[J]	2.9[U]

*There are no published *g*(0) values for *Kogia* spp. Because of lack of *g*(0) and because only two of the 83 sightings of *Kogia* spp. were from aerial surveys, we did not include aerial sightings of *Kogia* spp. in our analysis.

Aerial Trackline CetMap = 462,000 km (Roberts et al 2015)
Aerial Trackline AMAPPS 2010-2014 = 59,632 km (AMAPPS 2010, 2011, 2012, 2013, 2014)
Total Aerial Trackline = 521,632 km
Vessel Trackline CetMap = 28,000 km (Roberts et al 2015)
Vessel Trackline AMAPPS 2010-2014 = 10,488 km (AMAPPS 2010, 2011, 2012, 2013, 2014)
Total Vessel Trackline = 38,488 km
WesternGeco Full Array Trackline Distance = 27,331 km
WesternGeco Mitigation Source Distance = 985 km
Total WesternGeco Trackline Distance (full power & mitigation source) = 28,316
Percent of WesternGeco Trackline inside EEZ = 97%
WesternGeco Mean 160 dB (rms) radius for full power array = 6,838 m
WesternGeco Mean 160 dB (rms) radius for mitigation source = 1,486 m

[H] Carretta et al. (2000). Note these values are from Pacific surveys. There are no published values for the Atlantic.
[I] Barlow and Forney (2007). Note these values are from Pacific surveys. There are no published values for the Atlantic.
[J] Palka (2006)
[K] Palka (1995)
[L] Palka (2012) specifically evaluated ESWs for an aerial platform for harbor porpoise (n=173), minke whales (n=19), and fin whales (n=7) for an aerial platform and reports the unpooled results. These data appear to be the best published estimates specific to these species, despite low sample sizes for minke and fin whales. The "large whale" ESW reported in Mullin and Hoggard (2000) does not include any sightings of minke or fin whales, so they are not likely well

represented by that estimate. Palka (2012) specifically evaluates ESWs for a vessel platform for *Kogia* spp. (n=32), minke whales (n=18) and fin whales (n=46). Mullin and Fulling (2003) included only 1 fin whale, 1 minke whale, and 8 *Kogia* spp. sightings in their pooled ESW estimates for ship-based surveys.
[M] Mullin and Hoggard (2000) Gulf of Mexico aerial surveys. We were unable to find published ESW estimates for these species for an aerial platform in the Atlantic. *Kogia* spp. were pooled with "cryptic whales," rough-toothed dolphins were pooled with small whales/large dolphins, and Clymene and pantropical spotted dolphins were pooled with small dolphins for evaluated ESWs in Mullin and Hoggard (2000).
[U] Mean from 2,047 groups, most of which were north of the proposed TGS seismic survey area in CeTAP (1982)
[V] Mean from 518 groups, one of which was south of Long Island, in CeTAP (1982)
[X] From Fertl et al. (2003)
[Y] Highest value from Palka (1995)
[Z] Mullin and Fulling (2003). Clymene and pantropical spotted dolphins were pooled with "small dolphins" for evaluated ESWs in Mullin and Fulling (2003). We did not find published ESWs for these species individually from a ship-based platform in the Atlantic or Gulf of Mexico.

Table 6-4. Results of applying the approach detailed in Section 6.3 for potential exposure estimates for uncommon species based on trackline sightings. Results for the full array and for the mitigation source are provided, along with the sum of these results, which represents the total estimated potential ≥ 160 dB (rms) exposures based on aerial and vessel surveys in the proposed WesternGeco seismic survey region. See Tables 6-1 to 6-3 for sources of values used in Table 6-4.

Step 1

Total Transect Area Surveyed (km^2) with 100% of Groups Observed (based on Line-Transect Theory definition of Effective Strip Width).

	2 X ESW X Transect Line Length	
	Aerial (km^2)	**Vessel (km^2)**
Clymene dolphin	831,481	386,804
Harbor porpoise	194,047	20,060
Kogia spp.	727,155	142,329
Pantropical spotted dolphin	831,481	386,804
Rough toothed dolphin	808,530	309,136
Minke whale	384,964	88,599
Fin whale	354,710	154,568

*ESW = Effective Strip Width. See Table 6.3 for ESW values and their sources.

Step 2

Density in Transect Bounded by ESW.

	Sightings / km^2			***Individuals / km^2 = Sightings/km^2 X Mean Group Size***	
	Aerial	**Vessel**	**Mean Grp Size**	**Aerial**	**Vessel**
Clymene dolphin	0.000005	0.000026	76.1	0.000366	0.001967
Harbor porpoise	0.000052	0.000000	2.93	0.000151	0.000000
Kogia spp.		0.000569	1.9		0.001081
Pantropical spotted dolphin	0.000004	0.000041	77.5	0.000280	0.003206
Rough toothed dolphin	0.000012	0.000019	14	0.000173	0.000272
Minke whale	0.000068	0.000011	1.5	0.000101	0.000017
Fin whale	0.000186	0.000142	2.9	0.000540	0.000413

Sighting numbers provided in Table 6-3 are the sum of AMAPPS surveys and surveys included in CetMap (also see Tables 6-1 and 6-2); Area in km^2 provided in Step 1.

Step 3

Density estimates corrected for bias with *g*(0) values.

	Individuals / km² / g(0)		
	Aerial	**Vessel**	**Average**
Clymene dolphin	0.000368	0.002028	0.001382
Harbor porpoise	0.000419	0.000000	0.000419
Kogia spp.		0.003089	0.001545
Pantropical spotted dolphin	0.000281	0.003305	0.001934
Rough toothed dolphin	0.000180	0.000317	0.000339
Minke whale	0.000262	0.000024	0.000275
Fin whale	0.001221	0.000439	0.001440

See Table 6.3 for *g*(0) values and their sources.

Step 4

Potential Number of Marine Mammals Modeled to be Exposed to 160 dB (rms) in WesternGeco Seismic Survey.

	Corrected Density X Trackline X Radius X 2			***In EEZ Only (97%)***
	Mitigation	**Full Power**	**Total (Sum)**	
Clymene dolphin	4	517	521	505
Harbor porpoise	1	157	158	153
Kogia spp.	5	577	582	564
Pantropical spotted dolphin	6	723	728	707
Rough toothed dolphin	1	127	128	124
Minke whale	1	103	103	100
Fin whale	4	538	543	526

97% of WesternGeco trackline is inside the U.S. EEZ.

Further detailed discussion of uncommon species and exposure estimates follows.

6.3.2 Clymene Dolphin

One uncommon species was the Clymene dolphin. Roberts et al. (2015) reported a total of 11 sightings for CetMap analyses, 10 of which were off the North Carolina (NC) and Virginia (VA) shelf near the Gulf Stream, with 1 additional sighting made off the coast of Georgia (GA). This is much less than the minimum 60-80 sightings recommended by Buckland et al. (2001) for distance sampling. Roberts et al. (2015) chose to split the 10 sightings off NC/VA and the 1 off GA into 2 groupings and spread densities based on a uniform model (because lack of sightings made it impossible to assess environmental characteristics that might be associated with Clymene dolphin distribution). As a result, 2 density estimates of Clymene dolphins were spread across 10 km² grids in the area of the EEZ. One density was inside of and 1 density was outside of the 100 m isobath, and both were kept below 50 km north of the northernmost sighting of Clymene dolphins. Above that area, density was set to zero. As a result of this approach, densities of Clymene dolphins are estimated to be the same across most of the Mid- and South-Atlantic EEZ, regardless of habitat parameters and regardless of the fact that sightings were mainly clustered off NC/VA shelf. Because of this, the CetMap density estimates are not necessarily ideal for estimating exposures of Clymene dolphins across a large area. This is because the assumptions and resulting uncertainty/error associated with the density estimates are magnified with each additional 10 km^2 grid square included in the analysis.

That said, there are Clymene dolphins in the proposed seismic survey area, so an exposure estimate is warranted. The exposures were calculated as described in Section 6.3 and shown in Table 6-4.

6.3.3 Harbor Porpoise

Another uncommon species in the proposed seismic survey area is harbor porpoise. Although quite common north of the proposed WesternGeco survey area (i.e., they are considered a Gulf of Maine/Bay of Fundy stock by NMFS [Waring et al. 2015]), there were no sightings of this species in the proposed seismic survey area in the dataset used in CetMap (Roberts et al. 2015). Because the densities south of about 39°N are not based on any sightings in CetMap, we suggest that the same problems apply to using CetMap for estimating exposures of this species as were described for Clymene dolphins in Section 6.3.2 above. Based on AMAPPS (2011) data, AMAPPS (2012) reported a preliminary abundance estimate of harbor porpoise in the SEFSC survey area south of 40°N. However, there were 8 sightings of 14 individuals in the proposed seismic survey area (off Maryland/Delaware, Virginia, and North Carolina) during winter 2013 surveys (AMAPPS 2013). We therefore believe an exposure estimate is warranted for this species, despite no sightings in the region during surveys included in CetMap.

As described for Clymene dolphins above, we can estimate exposures based on survey sightings per trackline distance in comparison with trackline distance proposed by WesternGeco. Using the same equations as for Clymene dolphins, we estimated exposures for harbor porpoise (Table 6-4).

6.3.4 *Kogia* Species

Kogia spp. were also uncommon; Roberts et al. (2015) reported a total of 31 sightings used for CetMap analysis. This is less than the 60-80 recommended by Buckland et al. (2001) for distance sampling. These sightings were spread throughout the EEZ south of about 40°N. Roberts et al. (2015) chose to split the EEZ into two parts and spread densities based on a uniform model (because lack of sightings made it impossible to assess environmental characteristics that might be associated with *Kogia* spp. distribution). As a result, 2 density estimates of *Kogia* spp. were spread across the 10 km^2 grids in the area of the EEZ. Density on the shelf was set to zero/km^2. As a result of this approach, densities of *Kogia* spp. are estimated to be the same across most of the Mid- and South-Atlantic EEZ, regardless of habitat parameters. Because of this, the CetMap density estimates are not necessarily ideal for estimating exposures of *Kogia* spp. across a large area. As stated above, this is because the assumptions and resulting uncertainty/error associated with the density estimates are magnified with each additional 10 km^2 grid square included in the analysis. Also, only 19 groups were seen during surveys in the proposed seismic survey area included in CetMap, while 67 additional groups were observed during AMAPPS surveys, making it important to include AMAPPS data in analysis of these species.

The exposures were calculated as described in Section 6.3 and shown in Table 6-4.

6.3.5 Pantropical Spotted Dolphin

Another uncommon species was pantropical spotted dolphins. Roberts et al. (2015) reported a total of 17 sightings for CetMap analyses, most of which were south of 35°N. This is less than the 60-80 recommended by Buckland et al. (2001) for distance sampling. Roberts et al. (2015) chose to split the EEZ into 3 parts and spread densities based on a uniform model (because lack of sightings made it impossible to assess environmental characteristics that might be associated with pantropical spotted dolphin distribution). As a result, 3 density estimates of pantropical spotted dolphins were spread across the 10 km^2 grids in the area of the EEZ. Density on the northeast shelf above 35°N was set to zero, whereas density on the southeast shelf below 35°N on the slope and abyss were set at two differing densities. As a result of this approach, densities of pantropical spotted dolphins are estimated to be the same across most of the Mid- and South-Atlantic EEZ, regardless of habitat parameters. Because of this, the CetMap density estimates are not necessarily ideal for estimating exposures of pantropical spotted dolphins across a large area as the assumptions and resulting uncertainty/error associated with the density estimates are magnified with each additional 10 km^2 grid square included in the analysis.

That said, there are pantropical spotted dolphins in the proposed seismic survey area, so an exposure estimate is warranted. Using the same equations as for Clymene dolphins, we estimated exposures for pantropical spotted dolphins (Table 6-4).

6.3.6 Rough-toothed Dolphin

Rough-toothed dolphins were uncommon as well. Roberts et al. (2015) reported a total of 11 sightings for CetMap analyses, all of which were south of 37°N. This is less than the 60-80 recommended by Buckland et al. (2001) for distance sampling. Roberts et al. (2015) chose to split the EEZ into two parts with density of zero in the northern area of the EEZ. Density was based on a uniform model (because lack of sightings made it impossible to assess environmental characteristics that might be associated with rough-toothed dolphin distribution). As a result, one density estimate of rough-toothed dolphins was spread across the 10 km^2 grids in part of the EEZ. With this approach, density of rough-toothed dolphins is estimated to be the same across most of the Mid- and South-Atlantic EEZ, regardless of habitat parameters. Because of this, the CetMap density estimates are not necessarily ideal for estimating exposures of rough-toothed dolphins across a large area as the assumptions and resulting uncertainty/error associated with the density estimates are magnified with each additional 10 km^2 grid square included in the analysis.

That said, there are rough-toothed dolphins in the proposed seismic survey area, so an exposure estimate is warranted. Using the same equations as for Clymene dolphins, we estimated exposures for rough-toothed dolphins (Table 6-4).

6.3.7 Minke Whale

Minke whales, although quite common north of the proposed survey area (i.e., they are considered a Canadian East Coastal stock by NMFS [Waring et al. 2015]), there were only 17 sightings of this species in the proposed WesternGeco seismic survey area in the dataset used in CetMap (Roberts et al. 2015). Because the densities south of about 39°N are only based on 17 sightings in CetMap, we suggest that the same problems apply to using CetMap for estimating exposures of this species as were described for Clymene dolphins in Section 6.3.2 above. This is less than the 60-80 recommended by Buckland et al. (2001) for distance sampling.

Minke whales have some seasonal shifts in abundance in which there are more observed during summer in the Gulf of Maine/Bay of Fundy area (Roberts et al. 2015, CETAP 1982). However, despite survey coverage south of 39°N in the Atlantic EEZ during winter, minke whales have rarely been seen there (Roberts et al. 2015, AMAPPS 2010, 2011, 2012, 2013, CETAP 1982), suggesting they may overwinter elsewhere. AMAPPS (2012) reported 5 sightings of 6 individuals in winter/spring surveys, AMAPPS (2013) reported 3 individuals, and AMAPPS (2014) reported 2 individual in the northern part of the proposed WesternGeco seismic survey area. Based on AMAPPS (2011) data, AMAPPS (2012) reported a preliminary abundance estimate of zero minke whales in the SEFSC survey area south of 40°N. CETAP (1982) reported only 1 individual south of Long Island in the fall. Because of the paucity of sightings of minke whales south of 39° N, it is unlikely that minke whales will be encountered commonly in this area.

Based on data constraints, Roberts et al. (2015) chose to split the EEZ into 3 parts, with the area north of 35°N including a habitat-related model. From November to March, in the area south of about 35°N, minke whale density was set to zero on the shelf. A density based on a uniform model was used on the slope and abyss areas (because lack of sightings made it impossible to assess environmental characteristics that might be associated with minke distribution). As a result, one density estimate of minke whales was spread across the 10 km^2 grids in part of the EEZ. Because of this approach, density of minke whales is estimated to be the same across most of the Mid- and South-Atlantic EEZ south of about 35°N in CetMap, regardless of habitat parameters. As such, the CetMap density estimates are not necessarily ideal for estimating exposures of minke whales in that area because the assumptions and resulting uncertainty/error associated with the density estimates are magnified with each additional 10 km^2 grid square included in the analysis.

That said, there are minke whales the proposed seismic survey area, so an exposure estimate is warranted. Using the same equations as for Clymene dolphins, we estimated exposures for minke whales (Table 6-4).

6.3.8 Fin Whale

Another uncommon species was fin whales. Although quite common north of the proposed survey area, there were only 49 sightings of this species in the proposed WesternGeco seismic survey area in the dataset used in CetMap (Roberts et al. 2015). Because the densities south of about 39°N are only based on 49 sightings in CetMap, we suggest that the same problems apply to using CetMap for estimating exposures of this species as were described for Clymene dolphins in Section 6.3.8 above. This is less than the 60-80 recommended by Buckland et al. (2001) for distance sampling.

Watkins et al. (2000) reports that fin whales may not make large seasonal movements like other baleen whales, so possibly fin whales mainly stay in the northern regions of the North Atlantic throughout the year. However, CETAP (1982) reported some seasonal fluctuation in the number of sightings of fin whales, with decreased sightings in winter, though they noted that fin whale abundance did not change through the year from Cape Ann to Cape Cod area and around Georges Bank. Areas immediately east of Cape Cod experienced an increase in fin whale abundance in spring and summer and also increased in winter and spring east of Delaware (the northernmost area included in the proposed WesternGeco seismic survey area is Maryland, just south of Delaware). Results of AMAPPS surveys in the SEFSC are shown in Table 6-1. Given that survey coverage during the 5 years of AMAPPS surveys extended below 35°N, in some years extending below 30°N, it seems likely that fin whales tend to mainly stay in the northern latitudes along the U.S. east coast. They may, however, migrate to other areas at latitudes closer to the equator as the studies reported are limited to the coastal U.S. EEZ. Roberts et al. (2015) report that no sightings were reported south of 33°N in the surveys included in their density models, though they note 1 sighting off Georgia "recently," acoustic data including potential migration past Bermuda to the West Indies, and 1 stranding in the Bahamas.

Despite a lack of sightings in the region south of 35°N, Roberts et al. (2015) modeled densities of fin whales that includes higher density areas along the shelf south to 26°N. As with the cases described above, this may be good with respect to making sure localized projects consider the possibility of a small density of fin whales in the region south of 35°N. However, when these densities are used to estimate exposures over a large area of seismic survey activity, the assumption that fin whales occupy each of the grid areas where they have never or very rarely been seen is compounded to create an inflated exposure estimate. Given that these estimates are based on less than the Buckland et al. (2001) suggested 60-80 sightings and given the magnification of uncertainty/error associated with large-scale exposure estimates, we have estimated fin whale exposures based on the same method used above for species for which CetMap has spread uniform densities across large areas of the EEZ.

There are fin whales in the proposed seismic survey area, so an exposure estimate is warranted. Using the same equations as for Clymene dolphins, we estimated exposures for fin whales (Table 6-4).

6.4 Abundance Estimates

Estimates of abundance for each species can be compared to the number of individuals estimated to potentially be exposed to 160 dB (rms) sound levels for each species or species group. We make such comparisons in Table 6-5. Abundance estimates are available in SARs (Waring et al. 2014, 2015) for most species. However, Roberts et al. (2015) provide updated abundance estimates based on the data included in CetMap, which in some cases are more appropriate for comparisons with exposure estimates. For example, if the SAR reports an estimate of 100 of a species, but extrapolation of CetMap densities (density x area) results in a total of 500 individuals, this difference must be considered when exposure estimates are estimated based on an assumption of 5 times the abundance reported in the SAR. On the other hand, in some cases, SAR abundance estimates include a larger area of the species range or are based on more sightings than CetMap estimates, making SAR reported abundance estimates more reflective of actual population sizes. As such, abundance estimates described in the SAR and Roberts et al. (2015) were evaluated for each species on a case by case basis relative to available information. In several cases, the SAR estimate was based on the Canadian Trans-North Atlantic Surveys in 2007 which covered the largest area of the stock's range, making it a more comprehensive estimate than that provided by Roberts et al. 2015. Roberts et al. (2015) report various abundance estimates based on different seasons and models. The highest estimate provided should correspond to the greatest densities in CetMap and best represent an abundance estimate associated with using CetMap densities for modeling exposures. A summary follows (see Table 6-5 also):

Minke whale: 20,741 (CV 0.30) derived from Canadian Trans-North Atlantic Surveys in 2007, which is the survey with best coverage of the range of this stock (Waring et al. 2015).

Sei whale: 1,742 (no CV) derived from CetMap data 1995-2013 (~821 sightings); this is a more comprehensive dataset than the SAR estimate based solely on AMAPPS 2011 (~10 sightings, though also a few ambivalent sei/fin whale sightings).

Bryde's whale: not applicable (N/A). Although Roberts et al. (2015) reported 7 (CV 0.58) derived from CetMap data 1992-2014, this was based on 4 sightings from 1992-2014; no additional sightings occurred during AMAPPS surveys 2010-2014; and no sightings were reported during CETAP (1982); there is no Western North Atlantic SAR for Bryde's whales.

Blue whale: 440 (no CV) derived from individuals photo-identified 1979-2009 in the Gulf of St. Lawrence as reported in the SAR, which concludes population size is likely to be between 400 and 600 (Waring et al. 2015); there are only 8 sightings in CetMap, so photo-identification estimates are likely a better indicator of population size.

Fin whale: 3,522 (CV 0.27) derived from Canadian Trans-North Atlantic Surveys in 2007, which is the survey with best coverage of the range of this stock (Waring et al. 2015).

North Atlantic right whale: 465 derived from additional review of the photo-identification database in 2013 and reported as the minimum estimate in the SAR (Waring et al. 2015).

Humpback whale: 2,102 (no CV) derived from CetMap data 1995-2013 (2,732 sightings); there are a variety of surveys described in the SAR, including an estimate of 2,612 (CV 0.26) (Lawson and Gosselin 2011) from the 2007 Canadian Trans-North Atlantic Surveys; because approximately 39% of individuals observed along the Mid- and South-Atlantic U.S. coast are from the Gulf of Maine stock based on photo-identification (Barco et al. 2002), it is difficult to use this stock abundance alone to compare to exposure estimates; given exposures were calculated based on CetMap, using CetMap derived abundance seems to best deal with the issue of multiple stocks in the area.

Short-beaked common dolphin: 161,110 (no CV) derived from CetMap data 1992-2014 (~1,187 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are higher at 173,486 (CV 0.55) (Waring et al. 2015); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider.

Pygmy killer whale: N/A; there is no abundance estimate in the SAR and no density or abundance estimates in Roberts et al. (2015); there was 1 sighting of this species in CETAP (1982).

Pilot whale: 48,050 (21,515 [CV 0.37] for short-finned and 26,535 [CV 0.35] for long-finned) (Waring et al. 2015); short-finned estimates were derived from 2011 surveys from Florida to the Bay of Fundy (Palka 2012), covering the species' range into Canada; long-finned estimates were derived from 2006 surveys covering southern Gulf of Maine to upper Bay of Fundy and Scotian Shelf (Palka 2006), also covering the species' range into Canada.

Risso's dolphin: 12,929 (no CV) derived from CetMap data 1998-2013 (~721 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are higher at 18,250 (CV 0.46) (Waring et al. 2015); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider, though it is likely if AMAPPS data were incorporated into CetMap the estimate would increase.

Northern bottlenose whale: N/A. Although Roberts et al. (2015) reported 90 (CV 0.63) derived from CetMap data 1992-2014, this was based on 4 sightings from 1992-2014; none were observed during AMAPPS surveys; 2 groups were seen during CETAP (1982) surveys; no abundance is reported in the SAR (Waring et al. 2015).

***Kogia* spp.**: 7,570 is two times the SAR (Waring et al. 2015) estimate which is 3,785 (CV 0.47) derived from 2011 AMAPPS surveys (Palka 2012); Waring et al. (2015) states that the estimate of 3,785 was not corrected for availability bias and the corrected estimate could be 2-4 times higher; using two times the estimate is a conservative approach that uses a more realistic value for *Kogia* spp. abundance; CetMap estimated 678 (CV 0.23) in the U.S. Atlantic EEZ, which is less than the SAR; however it is likely this difference is related to the difference in the number of sightings used to make the estimates; for the CetMap dataset, there were only 31 sightings, but in AMAPPS (2011), there were 43; as there were an additional 68 sightings in AMAPPS 2013, it is likely the abundance estimate would increase with the inclusion of AMAPPS data in CetMap.

Atlantic white-sided dolphin: 70,639 (no CV) derived from CetMap data 1995-2014 (~2,266 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are lower at 48,819 (CV 0.61) (Waring et al. 2015); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider.

Fraser's dolphin: N/A. Although Roberts et al. (2015) reported 492 (CV 0.76) derived from CetMap data 1992-2014, this was based on 2 sightings from 1992-2014; no additional sightings occurred during AMAPPS surveys 2010-2014; no sightings were reported during CETAP (1982); no abundance is reported in the SAR (Waring et al. 2015).

Beaked whales: 14,491 (no CV) derived from CetMap data 1998-2013 (~226 sightings); a combined 13,624 *Mesoplodon* spp. (7,092 [CV 0.54]) and Cuvier's beaked whale (6,532 [CV 0.32]) estimate is provided in the SAR but is based on fewer sightings of beaked whales (52) from 2011 AMAPPS surveys (Palka 2012, Waring et al. 2015).

Killer whale: N/A. Although Roberts et al. (2015) reported 11 (CV 0.82) derived from CetMap data 1992-2014, this was based on 4 sightings from 1992-2014; 1 group was observed during AMAPPS 2014 spring surveys and 12 groups were reported during CETAP (1982); no abundance is reported in the SAR (Waring et al. 2015).

Melon-headed whale: N/A. Although Roberts et al. (2015) reported 1,175 (CV 0.50) derived from CetMap data 1992-2014, this was based on 4 sightings from 1992-2014; none were observed during AMAPPS and CETAP (1982) surveys; no abundance is reported in the SAR (Waring et al. 2015).

Harbor porpoise: 54,205 (no CV) derived from CetMap data 1995-2013 (~2,018 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are higher at 79,883 (CV 0.32) (Waring et al. 2015); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider.

Sperm whale: 5,747 (no CV) derived from CetMap data 1992-2014 (~501 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are lower at 2,288 (CV 0.28) (Waring et al. 2015); however, given the CetMap estimate is based on more data across a broader range, it seems the most appropriate estimate to consider.

False killer whale: 442 (CV 1.06) derived from summer 2011 surveys from central Florida to the lower Bay of Fundy (Waring et al. 2015); this is the first stock assessment report for this species in this region; sightings of false killer whales have not occurred or have been rare during surveys in U.S. Atlantic waters (Waring et al. 2015).

Pantropical spotted dolphin: 4,406 (CV 0.33) derived from CetMap data 1992-2013 (~17 sightings); the best estimate in the SAR of 4,439 (no CV) is derived from two 2004 surveys and thus outdated (Waring et al. 2014).

Clymene dolphin: 12,515 (CV 0.56) derived from CetMap data 1992-2013 (~11 sightings); the best estimate in the SAR of 6,086 (CV 0.93) is from 1998 and thus outdated Waring et al. 2014).

Striped dolphin: 117,921 (no CV) derived from CetMap data 1992-2014 (~195 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are lower at 54,807 (CV 0.30) (Waring et al. 2014); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider.

Atlantic spotted dolphin: 58,002 (no CV) derived from CetMap data 1998-2013 (~838 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are lower at 44,715 (CV 0.43) (Waring et al. 2014); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider

Spinner dolphin: N/A. Although Roberts et al. (2015) reported 262 (CV 0.93) derived from CetMap data 1992-2014, this was based on 2 sightings from 1992-2014; there were no sightings during AMAPPS surveys and 4 sightings during CETAP (1982) surveys; no abundance is reported in the SAR (Waring et al. 2014).

Rough-toothed dolphin: 532 (CV 0.36) derived from CetMap data 1992-2014 (~11 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are lower at 271 (CV 1.00) (Waring et al. 2014); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider.

Bottlenose dolphin: 97,476 (no CV) derived from CetMap data 1992-2014 (~4,657 sightings); SAR abundance estimates based on AMAPPS surveys in 2011 are lower at 77,532 (CV 0.40) (Waring et al. 2014); however, given the CetMap estimate is based on more data, it seems the most appropriate estimate to consider.

Table 6-5. Estimated number of cetaceans that might be exposed to Level B (≥ 160 dB [rms]) received pulsed seismic sound levels during WesternGeco's proposed 2D seismic survey in BOEM's Mid-Atlantic and South Atlantic planning areas. Numbers are conservative and over-represent expected numbers of actual exposures (see Section 6 text). No exposures of pinnipeds or white-beaked dolphins are expected to occur as a result of proposed seismic operations given their known distributions, similar to the BOEM PEIS (BOEM 2014a) and other Atlantic IHAs (e.g., USGS 2014).

Species	Estimated Exposures in EEZ	Estimated Individuals Exposed in EEZ*	Abundance Estimate[X]	% of Abundance Exposed (based on individuals exposed)	Estimated Exposures outside EEZ	Total Estimated Exposures	Requested Level B Harassment Authorization
Exposures Modeled as Mean Group Size (See Section 6.3 for details)							
Sei whale	2	2	1,742	0.115%	0	2	2
Bryde's whale	2	2	N/A	N/A	0	2	2
Blue whale	1	1	440	0.227%	0	1	1
Pygmy killer whale	4	4	N/A	N/A	0	4	4
Northern bottlenose whale	2	2	N/A	N/A	0	2	2
Fraser's dolphin	243	243	N/A	N/A	8	250	250
Killer whale	7	7	N/A	N/A	0	7	7
Melon-headed whale	49	49	N/A	N/A	1	50	50
False killer whale	10	10	442	2.195%	0	10	10
Spinner dolphin	42	42	N/A	N/A	1	43	43
Atlantic white-sided dolphin	47	47	70,639	0.066%	1	48	48
Exposures Modeled Using Line-Transect Theory (See Section 6.3 for details)							
Common minke whale	100	76	20,741	0.366%	3	103	103
Fin whale	527	400	3,522	11.366%	16	543	543
Kogia spp.	565	429	7,570	5.668%	17	582	582
Harbor porpoise	153	116	54,205	0.215%	5	158	158
Pantropical spotted dolphin	706	537	4,406	12.181%	22	728	728
Clymene dolphin	505	384	12,515	3.069%	16	521	521

Species	Estimated Exposures in EEZ	Estimated Individuals Exposed in EEZ*	Abundance Estimate[X]	% of Abundance Exposed (based on individuals exposed)	Estimated Exposures outside EEZ	Total Estimated Exposures	Requested Level B Harassment Authorization
Rough-toothed dolphin	124	94	532	17.737%	4	128	128
Exposures Modeled Using CetMap Densities (See Section 6.2 for details)							
North Atlantic right whale	6	4	465	0.951%	0	6	6
Humpback whale	48	36	2,102	1.718%	0	49	49
Short-beaked common dolphin	20,308	15,434	161,110	9.580%	628	20,936	20,936
Pilot whale	4,623	3,513	48,050	7.312%	143	4,766	4,766
Risso's dolphin	1,578	1,199	12,929	9.277%	49	1,627	1,627
Beaked Whales (Mesoplodon spp. & Cuvier's)	4,942	3,756	14,491	25.920%	153	5,095	5,095
Sperm whale	1,941	1,475	5,747	25.668%	60	2,001	2,001
Striped dolphin	8,915	6,776	117,921	5.746%	276	9,191	9,191
Atlantic spotted dolphin	18,491	14,053	58,002	24.229%	572	19,063	19,063
Bottlenose dolphin++	23,134	17,581	97,476	18.037%	715	23,849	23,849

N/A = Not available or not assessed

Endangered species are shown in bold

[&] "Estimated exposures" was determined using the different approaches described in the text of Section 6. These are the final determination of potential exposures to 160 dB (rms) during WesternGeco's proposed seismic survey after evaluating model outputs and making any appropriate adjustments or applying correction factors as described in Section 6. They are conservative numbers which are considered overestimates of actual exposures for reasons discussed in Section 6.

[X] See Section 6.4 for sources of abundance estimates.

* Estimated individuals exposed accounts for the overlap in the ensonified areas in the model. Because the model is an instantaneous exposure model, it does not account for animal movement or time--the individuals are static in space and time. As such, overlap in areas modeled to be ensonified to 160 dB (rms) constitute exposures of the same individuals multiple times. The total area modeled to be ensonified was 392,860 km^2, and 186,956 km^2 of this was overlapping (or 48%). Total numerical output of the model (estimated exposures in Table 6-5) includes this overlap (i.e., if an individual was exposed in trackline A ensonification region and trackline B ensonification region, it was considered to be exposed twice). Therefore, the number of individuals potentially exposed (vs. total potential exposures) can be determined using the following equation: (Numerical Output of the Model) - (0.48 X Numerical Output of the Model) + 0.5 X (0.48 X Numerical Output of the Model) or simplified: 0.76 X Numerical Output of the Model. Because the model did not allow the ability to estimate overlap inside the EEZ separately from overlap outside the EEZ, the 48% overlap is applied to inside the EEZ in calculations in Table 6-5, as only 3% of the tracklines are outside of the EEZ.

^ Percent of abundance is a general comparison of the estimated potential number of individuals exposed to 160 dB (rms) during WesternGeco's proposed seismic survey to the most appropriate available abundance value as described in Section 6.4. This does not consider larger regional abundance of the species, making it a conservative comparison.

Includes two species: short and long-finned pilot whales.

Includes a total of five species: four *Mesoplodon* species and Cuvier's beaked whale.

++Considered offshore stock of bottlenose dolphin only.

6.4.1 Caveats

Estimates of the numbers of marine mammals that might be exposed and react to potential RLs of pulsed seismic sounds ≥160 dB re 1 μPa (rms) are provided in Table 6-5. This method does not account for likely movement of some animals away from the seismic source (described in Section 7) or implementation of PSO monitoring and mitigation measures expected to reduce and minimize the actual exposure level numbers.

The requested exposure estimates are considered precautionary, and thus overestimates, for the following reasons:

- The distance to the 160 dB re 1 μPa (rms) isopleth used to estimate exposures was based on a larger "surrogate" 5,400 in^3 array modeled by JASCO for the BOEM Atlantic PEIS (BOEM 2014a) for reasons discussed in Section 1.4.
- The exposure estimates assume that the full seismic source array will operate continuously along all seismic lines. However, this is unlikely to occur. Adverse weather conditions and potential equipment delays are expected to curtail operations, as routinely occurs during offshore surveys (e.g., Cate et al. 2014). It is likely, for example, that seismic operations in winter will be curtailed by the typically rough weather of the Atlantic Ocean at this time.
- Any marine mammal sightings made within or near the designated EZ will result in the shut down or power down of seismic operations as a mitigation measure (see Section 11). While some animals may not be seen, particularly with increasing distance from the observation platform given the estimated 904 m EZ radius, sightings closest to the vessel have the highest likelihood of being seen based on visual detection function studies (e.g., Buckland et al. 2001, Cate et al. 2014, Moore and Barlow 2014).
- Not all individuals are expected to change their behavior significantly when exposed to seismic sounds ≥160 dB re 1 μPa (rms) based on a review of the best available data and studies (see Section 7).
- Delphinids have often been observed to voluntarily approach active seismic vessels including bow riding, with no conclusive observed signs of injury or mortality (e.g., reviewed in BOEM 2014a and Section 7).
- Proposed implementation of monitoring and mitigation measures including ramp-up and shut-down of the seismic source and operation of a smaller mitigation seismic source to alert animals is designed to reduce and minimize potential negative impacts to marine mammals (including temporary and permanent hearing impairment)
- Empirical data indicate that some animals move away from seismic sounds (see Section 7);
- Alternate areas of similar habitat value are available for marine mammals to temporarily vacate the survey area during the operation of the seismic source(s) to avoid acoustic harassment;

In summary, exposures of marine mammals to proposed seismic operations are expected to result in no more than short-term effects to individuals related primarily to temporary changes in behavior. Such effects are not expected to result in significant adverse impacts to individuals or populations based on available studies involving seismic operations over the last 30+ years. Furthermore, estimated exposure modeling assumes that individual marine mammals do not move when exposed to seismic sounds, which is unrealistic given data showing that many individuals move away from seismic sounds. Additionally, the vessel will be transiting at speeds of 4-5 kt while conducting seismic operations, and thus will quickly move out of the conservative EZ identified in analyses presented herein. Finally, mitigation is not considered in exposure estimates, making estimates unrealistically high.

6.5 Requested Level B "Take" Authorizations

Requested authorization of numbers of Level B "take" exposures presented in Table 6-5 were determined using several approaches relative to the availability, reliability, and age of species- or group-specific density and population estimate data for the WesternGeco project area and surrounding region. Furthermore, for reasons summarized in Section 6.4.1 above, the estimated numbers of individuals that may be exposed to proposed seismic sounds are likely overestimated.

6.6 Level A "Take" by Harassment Analysis

No Level A take is requested. Potential numbers of Level A "take" through potential harassment or non-lethal injury assuming no mitigation are presented in **Error! Reference source not found.**Appendix C, Table C 2. The latter numbers were determined using 12% of the potential Level A exposures for year 2015 calculated using the Southall et al. (2007) criteria in BOEM (2014b). This percent was obtained by dividing the distance of the trackline WesternGeco proposes to cover (26,641 km) by the distance of trackline used for estimates in the BOEM PEIS (217,850 km). The Southall et al. (2007) criteria are currently considered by a group of bioacoustics experts and NMFS to be the best available science for making Level A exposure estimates (Southall et al. 2007, NOAA 2013b). Zero exposures are estimated for listed species using this approach.

There are no known studies quantifying the effects of various mitigation and monitoring measures in reducing potential exposures of marine mammals to seismic sounds. Numerous studies have demonstrated that some individuals in some species exhibit behavioral avoidance of seismic noise. However, such studies are limited in scope, sample size, and/or involve species that do not occur in the Atlantic project area (e.g., Northeastern Pacific gray whales, bowhead whales), among other caveats. Furthermore, available studies increasingly indicate that an animal's response is related to behavior state (e.g., migrating or feeding), age, sex, reproductive state, etc. (e.g., Richardson et al. 1995, Robertson 2013). These studies are summarized in Section 7. Mitigation and monitoring efforts are expected to be sufficient to avoid Level A take of marine mammals (see Section 11).

7 Anticipated Impact on Species or Stocks

The anticipated impact of the activity upon the species or stock.

In the following sections we assess the anticipated impact of the proposed seismic project on the species and stocks of marine mammals occurring with the survey area. This assessment is based on a review of available data with an emphasis on studies focused on marine mammal responses to seismic sounds and other sounds associated with the proposed survey. This review includes a summary on what is known about the hearing sensitivity of marine mammals relative to the sound characteristics of seismic activities. Reviews on the subject of marine mammals and seismic surveys can be found in numerous documents (e.g., Richardson et al. 1995; NRC 2003, 2005; Southall et al. 2009) as well as the MSA OCS PEIS (BOEM 2014a). Herein, we reference these documents but focus on more recent studies to supplement the compiled information. Potential impacts are reviewed in subsections in the following order: (1) behavioral responses, (2) hearing impairment, (3) tolerance, and (4) stranding and masking. Species- or taxa-specific studies are reviewed as relevant and available.

Based on the ensuing review we anticipate that in general, impacts to marine mammals will be limited to a small number of short-term behavioral responses (e.g., brief changes in behavior, movement away from the activity, etc.). We consider it highly unlikely that any of the proposed activities would result in deleterious effects to individuals, such as temporary or permanent hearing impairment, or other direct physiological damage. To avoid the potential risk of exposures to seismic sound very close to the proposed array, we propose implementation of a Marine Mammal Monitoring and Mitigation Plan (4MP) (see Section 13) that includes a Protected Species Observer (PSO) program, PAM methods, and procedures to ramp-up using a 105 in^3 (or smaller) seismic source prior to full seismic source data collection. This should minimize and mitigate the potential for significant impact. Further, the combined assessment of multiple overlapping seismic survey activities in the Atlantic is not expected to result in a significant impact on populations or stocks of marine mammals based on recent complex modeling analyses conducted by BOEM (e.g., see BOEM 2014a).

Marine mammals rely heavily on sound for navigation, orientation, communication, and to sense their environment (Tyack and Clark 2000). They have good hearing sensitivity across a wide range of audio frequencies (Ketten 1992, 2000). Because of this, there is much concern about the potential negative effects of anthropogenic sounds, including those from seismic surveys, on marine mammals (e.g., Richardson et al. 1995; NRC 2003, 2005; Southall et al. 2009, Wright and Cosentino 2015, Nowacek et al 2015). Sound travels efficiently underwater, and low-frequency sound energy can propagate for considerable distances. Depending on the volume of the seismic sources, sounds can be detected at distances of several km to hundreds, even thousands of km from the source (Richardson et al. 1995; McCauley et al. 2000; Nieukirk et al. 2004, 2012). Seismic source arrays can inundate large volumes of the ocean with sound, and thus have the potential to impact individuals, as well as stocks of marine mammals.

Information about the effects of seismic surveys on marine mammals is limited, but there are some recent reviews that are focused on, or include discussions of, effects of seismic sources (e.g., Gordon et al. 2004; Nowacek et al. 2007; Weilgart 2013). Richardson et al. (1995) cautioned that results of different studies often are not comparable because sound levels (usually SLs) from seismic exploration are calculated and/or reported differently, including in different units, by researchers (Nowacek et al. 2007). The paucity of reliable information on the effects of seismic surveys on marine mammals is in part due to the difficulty of monitoring marine mammals in the wild. However, new acoustic-based technologies and analytical methods have greatly improved capabilities for monitoring and estimating these effects (Clark et al. 2009; Johnson et al. 2009; Van Parijs et al. 2009; Southall et al. 2012; Sousa-Lima et al. 2013).

Assessing the significance and severity of behavioral effects of anthropogenic sound exposure on marine mammals presents unique challenges due to the inherent complexity of behavioral responses and the contextual factors affecting them. The severity of responses can vary depending on characteristics of the sound source (e.g., moving or stationary, number and spatial distribution of sound source[s], similarity of the sound to predator's sounds, habituation, behavior state, and other relevant factors) (Richardson et al. 1995; NRC 2005; Southall et al. 2007; Wirsing et al. 2008; Bejder et al. 2009; Barber et al. 2010; Ellison et al. 2011).

Richardson et al. (1995) proposed 4 zones of influence around a sound source in which effects might be observed (also summarized by Gordon et al. 2004):

1. Zone of audibility – the area within which the sound is both above the hearing threshold and within the hearing range of the animals, and audible above the background noise;
2. Zone of responsiveness – the region within which behavioral reactions in response to the sound occur;
3. Zone of masking – the area within which the sound may mask biologically significant sounds; and
4. Zone of hearing loss, discomfort, or injury – the area within which the sound level is sufficient to cause Permanent Threshold Shifts (PTS) or Temporary Threshold Shifts (TTS) in hearing.

Potential effects (from least to most severe) can include perceptual effects (e.g., masking), behavioral disturbance, effects on hearing sensitivity (e.g., PTS and TTS), and indirect or cumulative effects that may lead to strandings.

For the purpose of this IHA, the potential observable behavioral reactions of marine mammals to sounds from seismic sources can be categorized into the following: attraction, avoidance, or no reaction (i.e., tolerance). Behavioral reactions such as avoidance of the survey vessels are possible, and even expected to occur, for many species. These reactions should be considered normal and biologically adaptive behaviors that, in most cases, function to reduce the exposure, and therefore, negative effects, of seismic surveys. It also should be noted that 'no reaction' does not mean that there are no effects, only that no change in behavior is observable. It is possible that adverse biological effects could occur, even when animals are attracted to seismic survey vessels (see section 7.2). It is also important to consider the context of behaviors when observations of potential reactions are made. For example, animals actively engaged in feeding activities may be less inclined to react to noise (Malme et al. 1985) than species engaged in other activities, such as resting or socializing.

It is quite difficult to estimate the effects of anthropogenic noise on free-ranging marine mammals. The criteria used to estimate the received sound levels that could potentially disturb marine mammals are based on limited behavioral observations from just a few species, which are used as proxies for other species. Detailed observational studies have been performed on just a few species, primarily humpback, gray, bowhead, and sperm whales. Fewer detailed data are available for other species of baleen whales and small toothed whales. For many species, there are no data, or very limited data on responses to marine seismic surveys.

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate the number of marine mammals that would be present within a distance, or 'zone of influence' (ZOI) of the proposed activities. This approach involves modeling sound propagation and estimating the number of animals exposed to sound levels above a specified threshold level of seismic source sound based on the best available species densities in the area. In most cases, this approach is conservative, as it usually overestimates the numbers of marine mammals that would be affected in some biologically important manner.

Proposed project activities potentially affecting marine mammals include seismic survey activities and operations associated with surveys. In certain situations, these activities are expected to result in temporary displacement of a small number of cetaceans within the EZ and possibly the DZ, but are not expected to result in significant disruption to important behaviors. If displacement should occur, we expect it most likely to happen when received noise levels of seismic related sounds are greater than 160 dB rms (re 1 μPa) based on the best available, albeit limited data, from empirical studies of a small number of species and individuals. Given such studies, impacts on marine mammal populations inhabiting the survey area are likely to be short-term and not biologically significant, and limited primarily to animals close to the potential disturbance source.

Anthropogenic noise produced by seismic activities has the potential to produce stress, disturbance, and behavioral responses in marine mammals if they are present within audible range of the seismic source array or other noise sources. In summary, based on information synthesized from NOAA and U.S. Navy (2001), NRC (2005), Southall et al. (2007) and others, exposure to sound from the proposed project is expected to be limited to potential short-term disturbance or displacement of some individuals. Project operations resulting in sound exposure less than RLs of 180 dB (re: 1 μPa) are not expected to disrupt important behaviors patterns in a biologically significant manner. Seismic-related or industry ship-related mortalities or injuries to large whale species have not been reported in areas when marine mammal observers have been used to monitor oil and gas exploration and development operations (NMFS 2012b). Mitigation measures included in this IHA would minimize the potential for any marine mammal to be within the EZ of an operating seismic source, thereby reducing the potential for behavioral responses in close proximity to the sound source. However, beyond the EZ, some individuals may respond behaviorally as indicated by of empirical results of studies of some marine mammal species, as summarized below.

7.1 Behavioral Response

Behavioral responses of marine mammals to anthropogenic noise are dependent on numerous factors, including species, age and sex class, prior experience and exposure to anthropogenic sounds, current behavior state, reproductive state, time of day, hearing sensitivity, ocean conditions, and other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007). In general, peak hearing sensitivity for cetaceans is usually closely correlated to the frequencies of vocalizations that they make. If a marine mammal reacts to an underwater sound by changing its behavior or moving to avoid a sound source, the biological impacts of that change may, or may not be important to the individual, the stock, or the population. For example, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on both individuals and the population could be important. Alternatively, if an animal only briefly responds to a sound or noise, and quickly resumes its original behaviors, it is highly unlikely that this would have a significant biological effect on its survivorship or reproduction.

Behavioral disturbance reactions can range from brief interruptions of activities (e.g., resting, feeding, or social interactions) to longer-term reactions, such as ceasing an activity or behavior, or in more extreme cases, displacement of animals from preferred habitats (Richardson et al. 1995; Tyack et al. 2011). Sensitization (becoming more sensitive to a stimulus over time) and habituation (becoming less sensitive or tolerant to a stimulus over time) are important behavioral phenomena to consider when examining the effects of anthropogenic sounds (Wartzok et al. 2004; Nowacek et al. 2007). A marine mammal(s) that reacts briefly to an underwater sound by changing its behavior or moving away is probably doing so to reduce the impacts of the stimulus and, thus, this behavior should be considered adaptive (i.e., beneficial for survival). Brief and infrequent changes to most behaviors are unlikely to be biologically significant to the individual, stock or population. However, if a sound source repetitively interrupts important behaviors, or displaces marine mammals from important feeding or breeding habitats for a prolonged period (i.e., weeks to months), then the impacts on individuals and populations have greater potential to be biologically significant (e.g., Lusseau and Bejder 2007; Weilgart 2007).

Behavioral reactions of marine mammals to noise can also include changes in acoustic behaviors, such as changes in the intensity (Parks et al. 2010; Holt et al. 2011), rates (Norris 1995), duration (Miller et al. 2000), or signal structure of an animal's call (Parks et al. 2010), to complete cessation of calling (McDonald et al. 1995; Parks et al. 2010; Castellote et al. 2012). Numerous approaches, mostly involving PAM technologies, have been used to investigate such effects. These methods can be costly to implement and analysis of the often large volumes of acoustic data that result from them requires significant effort and cost. Also, changes in behavior often can be difficult to interpret or relate to significant biological impacts on individuals or populations of marine mammals.

In summary, behavioral responses to stimuli such as seismic sounds can and do occur among some marine mammals and under some circumstances, but these reactions are anticipated to be limited to short-term responses. Related knowledge and studies specific to baleen and toothed whales are summarized below.

7.1.1 Baleen Whales

Hearing abilities of baleen whales have not been studied directly. However, they are believed to have good low-frequency hearing sensitivity based on the documented repertoire of call characteristics (Southall et al. 2007). The inner ear anatomy of the baleen whale is well adapted for detection of low-frequency sounds (Ketten 1998, 2000; Parks et al. 2007a; Ketten et al. 2013). In addition, behavioral evidence indicates that they hear well at frequencies below 1 kHz (Richardson et al. 1995; Frankel et al. 1995). The sound levels that baleen whales can detect below 1 kHz are most likely limited by ambient noise at the lowest frequencies (Clark and Ellison 2004). Because of the close overlap between presumed baleen whale hearing sensitivity and low-frequency peaks in the power spectrum of seismic source pulses, some researchers believe that baleen whales may be more sensitive to effects of seismic source noise than odontocetes, which have lower hearing sensitivity at low frequencies (Nowacek et al. 2007; Gedamke et al. 2011).

Due to the presumed relatively good hearing sensitivity of baleen whales at low frequencies, they are likely to hear seismic source pulses at distances of several km to hundreds, or even thousands of km away under good sound propagation conditions (Nieukirk et al. 2012). There is very limited information about how whales react to sounds at these distances, where received SLs would be expected to be well below the thresholds for potential TTS and PTS. Therefore, any negative effects likely would be limited to short-term behavioral reactions, displacement, or stress-related effects. There have been no dedicated studies focused on investigating the relationship between seismic surveys and stress in marine mammals. However, progress has been made in relating anthropogenic noise from shipping to stress by measuring stress responses via hormones or hormone metabolites (Rolland et al. 2012).

Recently, a few comprehensive studies based on a compilation of monitoring data during multiple seismic surveys have become available. For example, Moulton and Holst (2010) analyzed marine mammal sighting data collected during eight 3D seismic surveys off eastern Canada. Numbers of animals, sighting distances, and behavior of cetaceans were observed when seismic source arrays were fully operating, during ramp-up procedures used for mitigation, and for many periods when seismic sources were not operating. Observers watched for 9,180 hr from seismic vessels, including all daylight periods. During seismic surveys, baleen whales in particular showed localized avoidance of the actively operating seismic source array. In addition, sighting rates were significantly lower while the full seismic source array operated versus with when they were off. Reduced sighting rates during seismic operations suggest that some baleen whales avoided the source vessel by several km. Baleen whales were also seen significantly farther away from the source vessel (by approximately 200 m) during seismic compared to non-seismic periods. They were also observed to swim away from the vessel more often during seismic periods compared with non-seismic periods. These behavioral data suggest that, as a group, baleen whales avoided the seismic survey vessel during all seismic source-related operations.

In another compiled study, Stone and Tasker (2006) indicated that baleen whales demonstrated more 'localized' spatial avoidance than other cetacean species: they oriented away from the vessel and increased their distance from the source, but did not necessarily vacate the survey area. When sightings of minke, sei, and fin whales were combined, distances to animals were greater for sightings made during seismic surveys than those made at other times, suggesting an avoidance response.

Overall, there is good evidence that behavioral states of baleen whales such as feeding, migrating and resting affect their responses to seismic source sounds (Malme et al. 1985; McCauley et al. 1998, 2000; Gordon et al. 2004; Robertson et al. 2013). For example, Robertson et al. (2013) found that changes in the behavior of bowhead whales exposed to seismic operations were dependent on both whale activity (e.g., feeding, migrating, etc.) and contextual environment (e.g., season) among other factors. The RLs of sounds also impact the degree and type of response. For example, a review of seismic survey effects by Gordon et al. (2004) found that migrating whales and those individuals exposed to noise levels exceeding 150 dB exhibited the strongest reactions. Richardson et al. (1995) reported that some fall migrating bowhead whales avoided seismic source noise at RLs of ~120–130 dB (rms over pulse duration); however, while feeding during summer, bowheads appeared to be more tolerant of seismic noise with responses reported near RLs of ~158–170 dB. Species-specific information on behavioral responses to seismic noise is discussed below.

7.1.1.1 North Atlantic Right Whale

Right whales are believed to have good low-frequency hearing in the range of 10 Hz to 22 kHz based on anatomical measurements of 4 right whale ears and marine mammal hearing models (Parks et al. 2007b). Right whales produce a variety of low-frequency sounds usually consisting of short (< 2 sec) FM up-calls, low-frequency tonal calls, mid-frequency tonal calls, and pulsed low-frequency calls called gunshots (the latter which qualitatively sound similar to seismic source pulses) (Parks and Tyack 2005; Parks et al. 2005, 2011).

There are no documented visual observations of behavioral responses to seismic sources in right whales. However, changes in long- and short-term acoustic behaviors have been documented in both northern and southern right whales relative to shipping noise (Parks et al. 2007a). Changes included vocalizing at higher frequencies and increasing calling rates in response to increased shipping noise overlapping their call in frequency.

Nowacek et al. (2004) conducted controlled exposure experiments with sounds of a container vessel, conspecific calls, and "alerting" sounds. Multi-sensor acoustic recording tags (D-tags) on North Atlantic right whales were used to collect data. The alerting sounds consisted of: (1) alternating 1-sec pure tones at 500 and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 to 500 Hz; and (3) a pair of low-high (1,500 and 2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. The whales did not respond to noise from approaching vessels, but did respond strongly to alert sounds by swimming nearly immediately to the surface and remaining there until the alerting sound ended. They postulated that the animals may have been habituated to the vessel noise, and thus did not respond to playbacks of these sounds. They did not playback seismic source sounds so it is uncertain if animals would have responded to these sounds in a similar manner or not.

Rolland et al. (2012) found a positive correlation between stress and changes in shipping traffic noise by measuring hormone metabolites in the feces collected from North Atlantic right whales. It is not known whether or not seismic surveys would also increase stress in

North Atlantic right whales. However, these types of signals would presumably be perceived as noise by this species and it is possible that similar effects might occur.

In summary, based on available data on responses of right whales to shipping and other noise, North Atlantic right whales are anticipated to potentially respond in the short-term to seismic operations by changing their call characteristics. Behavioral responses to seismic sources have not been observed. However, based on responses of some individuals of other baleen whale species, such as the closely related bowhead whale, North Atlantic right whales are also likely to respond to seismic operations with short-term and localized movement away/displacement from active seismic operations and other more subtle behavioral changes. Because preferred and important habitat for this species occurs in the Mid-Atlantic Planning Area, potential impacts through exposure to proposed seismic operations are anticipated to be limited to this region of the survey area. However, WesternGeco's proposed mitigation and monitoring specifically for this species are expected to avoid and minimize such impacts. The latter includes avoiding exposure of critical habitat, SMAs, and DMAs to seismic survey noises greater than the NMFS' recommended 160 dB isopleth. Additional implementation of species-specific mitigation measures (e.g., seasonal and geographical closures—see Section 11) as well as the 4MP would further reduce the potential for adverse effects. No significant impacts to the population are anticipated given available studies on other baleen whale species and the proposed mitigation.

7.1.1.2 Blue Whale

Blue whales are expected to have good low-frequency hearing sensitivity (Ketten 2000; Ketten et al. 2013). Therefore, they would potentially exhibit responses to similarly low-frequency seismic survey noise. McDonald et al. (1995) tracked an individual blue whale during a seismic survey in the northeast Pacific using autonomous recorder data. The vocalizing whale was initially detected following a course that converged with the vessel. However, when the whale approached within 10 km of the seismic vessel, it stopped vocalizing and remained silent for an hr before resuming calling at a range of 10 km from the survey vessel. McDonald et al. (1995) estimated a RL of 143 dB (re: 1 μPa peak-to-peak [pk-pk] in the 10-60 Hz band) at the range at which the whale stopped vocalizing.

Blue whales in the St. Lawrence Estuary responded in the opposite manner based on a study that investigated low-level seismic survey noise from a low-to-medium power sparker (Di Iorio and Clark 2010). The mean sound pressure received by the recorders they deployed in areas where whales occurred indicated RLs of 131 dB re 1 μPa (pk-pk) (30–500 Hz) (mean SEL 114 dB re 1 μPa2- s [90% energy approach for duration estimate]; Madsen 2005). Blue whales called more (1) during days with seismic exploration noise than during days without seismic exploration noise, and (2) during periods within a seismic survey when the sparker was operating (Di Iorio and Clark 2010). This increase was observed for the discrete, audible calls typically emitted during social encounters and feeding. The authors hypothesized that this response represented behavior to compensate for the elevated ambient noise of the seismic survey operations. They suggested that noise from seismic surveys can reduce an individual's ability to detect socially relevant signals, and could therefore affect biologically important processes.

Moulton and Holst (2010) reported that blue whales were seen farther from the seismic ship during periods when seismic sources were on versus when they were silent, but the difference was small (a few tens of m).

In summary, based on available information, blue whales are expected to potentially respond to proposed seismic operations by exhibiting short-term acoustic and behavioral responses such as changing their acoustic behaviors (e.g., calling reduction or cessation in calling/singing rates). They are also likely to respond with short-term and localized avoidance of/displacement relative to active seismic operations based on limited studies on movements of blue whales near seismic surveys. Exposures of blue whales to proposed seismic operations are likely to be limited to deeper offshore waters based on the known preferred distribution and migratory pathways of this species in the survey area. Such effects would be reduced with implementation of mitigation measures as well as the 4MP (see Section 11). No significant impacts to the population are anticipated given available studies and reviews of seismic impacts on other baleen whale species.

7.1.1.3 Fin Whale

A number of relatively recent studies of fin whale behavior exposed to seismic noise have been conducted. Moulton and Holst (2010) found that the average distance to fin whale sightings from the seismic vessel was greater when seismic sources were on versus off, but the differences were not statistically significant. Based on the whales' closest point of approach (CPA) distance to the vessel, they were observed significantly farther from the source vessel during ramp up versus periods with no seismic sources operating; however, the sample size for ramp up periods was small.

In a large-scale, passive acoustic study, Clark and Gagnon (2006) monitored fin whales in the North Atlantic using the U.S. Navy's Sound Surveillance System (SOSUS) arrays. They noted that whales stopped singing and stayed silent when exposed to seismic source sounds from 3 or more seismic vessels operating simultaneously.

In another large-scale, long-duration study, numerous autonomous acoustic recorders (AARs) were deployed between 1999 and 2009 at 12 sites along the MAR to monitor seismic activity. The instruments were located within potential fin whale migration routes. Nieukirk et al. (2012) analyzed the data for 20-Hz fin whale pulses and seismic survey activity (i.e., seismic source pulses). Seismic source and fin whale sounds were recorded at all sites. Fin whales were presumed to be far (i.e., hundreds to thousands of km) from the source of noise, and direct effects (e.g., TTS, PTS) from seismic sources were therefore not likely. They believe that the most likely effect of the observed frequent seismic noise was a decrease in the effective range of communication among whales in the areas monitored. Nieukirk et al. (2012) noted that 20 Hz vocalizations overlap in frequency with seismic pulses, especially at very low frequencies. The authors cited Di Iorio and Clark (2010) in saying that "for animals engaged in long-term singing directed to a distant audience, information loss is minor if singing is temporarily interrupted". However, Nieukirk et al. (2012) suggested that if animals stop signaling for long periods of time, or avoid or abandon habitat, there could be significant population-level effects.

Recently, Castellote et al. (2012) demonstrated that fin whale singing activity and acoustic features of their signals (e.g., note duration, bandwidth, center frequency and peak frequency) were affected by the presence of seismic survey source operations in the western Mediterranean Sea. After the start of seismic surveys, the number of singing fin whales significantly decreased, RLs of song units decreased, and bearings to singers changed. Castellote et al. (2012) interpreted the combined observed changes as evidence that singers moved away from the seismic noise source. The effect was noticeable for 14 days after the seismic survey ended. Castellote et al. (2012) hypothesized that fin whales modify their acoustic behavior to compensate for increased background noise, and that a sensitization process may play a role in the observed temporary displacement.

In summary, based on available data, some fin whales are anticipated to potentially respond in the short-term to proposed seismic operations by changing their call characteristics (e.g., reducing or stopping calling behavior). They are also likely to respond with short-term and localized movement away/displacement from active seismic operations. Exposures of fin whales to proposed seismic operations would be limited primarily to spring, fall and winter when this species migrates through non-coastal deeper waters. Such effects would be reduced with implementation of mitigation measures as well as the 4MP (see Section 11). No significant impacts to the population are anticipated given available studies and reviews of seismic impacts on other baleen whale species.

7.1.1.4 Sei Whale

Because sei whales are difficult to distinguish from fin and Bryde's whales, they cannot be positively confirmed during analysis of visual data (Stone and Tasker 2006). Stone (2003) summarized reports from visual observers on seismic vessels operating in UK waters between 1998 and 2003. When sightings of minke, sei and fin whales were combined, ranges to animals were farther during seismic surveys versus other times. However, later analysis by Stone and Tasker (2006) from 201 seismic surveys in the same areas showed found no significant differences in sighting rates for combined fin and sei whales for periods when large seismic source arrays were on versus off. However, these whales exhibited localized avoidance, as sighting distances were further from the vessel during seismic-on verses seismic-off periods.

In summary, based mainly on data available for other baleen whales, some sei whales are anticipated to respond with short-term and localized movement away/displacement from active seismic operations; they may also respond with short-term changes in calling behaviors. Exposures of sei whales to proposed seismic operations would likely be limited to fall and spring migration periods in generally deep offshore waters. Such effects would be reduced with implementation of mitigation measures as well as the 4MP (see Section 11). No significant impacts to the population are anticipated given available studies and reviews of seismic impacts on other baleen whale species.

7.1.1.5 Common Minke Whale

Hearing sensitivity in minke whales has not been directly measured; however, like most baleen whales they are believed to have good low-frequency hearing (Ketten 1998, 2000; Yamato et al. 2012). The most common minke call types documented in the northwestern Atlantic Ocean are pulse trains (Mellinger et al. 2000). Associated peak frequencies range from ~55 Hz to 150 Hz and higher, depending on the type of pulse train (Winn and Perkins

1976; Mellinger et al. 2000; Risch et al. 2013); however, a high-frequency click component has recently been documented in some pulse trains (Hodge 2011). Acoustic responses of minke whales to seismic surveys have not been studied. A recent preliminary study of the effects of U.S. Navy activities (including vessel noise and mid-frequency active sonar [MFAS]) on minke whale vocalization events indicated a negative correlation between minke whale calling and U.S. naval activities (Norris et al. 2012). However, a more detailed and ongoing analysis has called into question a causal link between the 2 events (Cornell University, Bioacoustics Research Program 2014).

In general, minke whales are very elusive. Visual and acoustic observations indicate they tend to avoid noisy vessels, yet they have been observed in areas ensonified by seismic sources (Stone 2003; MacLean and Haley 2004; Stone and Tasker 2006). They have also been observed approaching an active seismic source survey vessel (MacLean and Haley 2004). A later study by Moulton and Holst (2010) found that minke whales were more likely to swim away and less likely to swim towards seismic vessels and also to mill when the full seismic source array was on versus off.

Stone and Tasker (2006) analyzed marine mammal sightings from 201 seismic surveys in United Kingdom (UK) waters. They found no significant differences in sighting rates for minke whales when large seismic source arrays were on operating versus off. Moulton and Holst (2010) reported that minke whales were on average ~400 m closer to the seismic vessel when seismic sources were off versus when the full seismic source array was on (μ = 963 m). Distances were not significantly different between when a single seismic source was on versus off. The same trends were observed for CPA distances.

In summary, based on available data, some minke are anticipated to potentially respond to proposed seismic operations with short-term behavioral response such changing their calling or singing behaviors (e.g., a reduction or cessation in calling/singing rates). They are also likely to respond with short-term and localized avoidance/displacement from active seismic operations based on responses of other baleen whale species. Such effects would be mitigated with implementation of species-specific mitigation measures (see Section 11) as well as the 4MP. No significant impacts to the population are anticipated given available studies and reviews of seismic impacts on other baleen whale species.

7.1.1.6 Humpback Whale

Behavioral responses of humpback whales to seismic surveys have been examined on their summer feeding grounds off Alaska (Malme et al. 1985), on their winter breeding grounds off Angola (Cerchio et al. 2014), and during migrations off Western Australia (McCauley et al. 2000). Each of these studies is reviewed in detail below.

In the mid-1980s, Malme et al. (1985) investigated effects of underwater noise from oil and gas industry activities on the behavior of feeding humpback whales. Their investigation was conducted in southeast Alaska during the fall and used a 100 in^3 seismic source as a controlled source for playback experiments to whales. Although they observed subtle effects, such as behavioral responses, they did not find clear evidence avoidance at exposure levels up to 172 dB (re 1 μPa) effective pulse pressure level. Seven of the 13 seismic sources and playback experiments resulted in statistically significant differences. In 3 of the 7 playbacks, there was a startle response, whereas 4 showed apparent avoidance of the seismic source by whales. Of the 4 avoidance responses, 1 was believed to be due more to boat drift than whale movements. Malme et al. (1985) believed that significant responses did not appear to scale with range, and were not stronger when animals were closer to the stimulus, as one would predict if they were responding directly to the RL of the stimulus. They hypothesized that the significant effects in movements of the humpbacks were likely due to either a response to some stimulus other than the seismic source, or were due to unaccounted drift of the sound source vessel. During many of the playback experiments, the humpback whales were apparently feeding, so Malme et al. (1985) considered the responses more likely a result of feeding patterns of the whales rather than due to influence by the sound source.

Data collected by observers during several seismic surveys in the Northwest Atlantic showed that sighting rates of humpback whales were significantly greater during non-seismic periods, compared with periods when a full array was operating (Moulton and Holst 2010). In addition, humpback whales were more likely to swim away from and less likely to swim towards a vessel during seismic versus non-seismic periods (Moulton and Holst 2010).

McCauley et al. (2000) monitored humpback whales exposed to seismic surveys around the Exmouth Gulf, off Western Australia, both as part of ongoing oil exploration surveys (using a 3D seismic source array with 2,678 in^3 seismic sources) and using a controlled exposure experimental design (a smaller 20 in^3 seismic source). As part of the observational component of the study, humpback whales were observed during their southward migration past Northwest Cape (near Exmouth). Aerial surveys, focal follows of individuals, acoustic monitoring from the survey vessels, and acoustic monitoring with remote sensors were used to monitor whales. For humpback whales migrating outside the 20 m depth contour, the major observable effect of a seismic survey vessel operating in the area of their migration route appeared to be limited to localized displacements near the seismic vessel. McCauley et al. (2000) did not find any indication of displacement or deflections of the whales' migration route off the coast. However, individual whales consistently changed course and speed to avoid close encounters with operating seismic arrays.

Based on 16 trials, McCauley et al. (2000) also reported that humpback groups containing females consistently avoided an approaching seismic source at a mean range of 1.3 km. Avoidance maneuvers were evident (before standoff) at ranges of 1.22 – 4.4 km. A startle response was observed once. The mean seismic source RL for avoidance was 140 dB re 1 µPa rms; the mean RLs for standoff range was 143 dB re 1 µPa rms; and the single startle response occurred at a RL of 112 dB re 1 µPa rms. These RLs are considerably less than those observed from the operating seismic vessel outside Exmouth Gulf, and from those reported for gray and bowhead whales. A summary of general responses of gray, bowhead and humpback whales versus RLs of seismic source sounds is provided for comparison in Table 7-1.

McCauley et al.'s (2000) analysis indicated that there was no discernible difference in the number of whales sighted per observation block (a 40 min period) when compared between observation blocks with the seismic source on or off for the entire block (based on visually observed data collected from the seismic survey vessel in offshore waters). For sighting data collected within 3 km of the survey vessel, sighting rates for seismic source off periods were considerably higher than for seismic source on periods. They concluded that (1) this variation suggested localized avoidance of the survey vessel when the seismic source was on, and (2) these results indicated that at some range most whales avoided an operating seismic vessel. Alternately, at distances over 3 km from the seismic vessel, sighting rates when the seismic source was on, were considerably higher than when the source was off. McCauley et al. (2000) suggested that the higher sighting rates observed at ranges over 3 km away during periods when the seismic source was on indicated that some bias existed in the availability of animals during periods when the seismic source was on; alternatively, this may have indicated that whales were attracted to the operating seismic source vessel.

In their review of McCauley et al.'s (2000) study, Nowacek et al. (2007) noted that humpback whales located at the water surface at a range 100 m away from the array would have most likely received lower sound levels than whales located well below the surface, due to variations in sound propagation and energy. Seismic arrays are designed to direct sound energy downwards; thus, it could be hypothesized that sound levels above the seismic source array would be lower than those below it--although this has not been studied in detail (Nowacek et al. 2007). Additionally, Urick (1983) found that sound pressure energy decreases to nearly zero when it approaches within a fraction of a wavelength of the water's surface; therefore, animals located near the water surface would likely experience decreased sound pressure.

Measurements and modeling of RLs of seismic sources in McCauley et al.'s (2000) study indicated that at specified ranges there were differences in the vertical sound intensity profile. A consistent trend of lower RLs towards the surface was observed. For the 3D seismic source array, a 6 dB decrease in level was measured with a decrease in depth of 40 to 5 m and at range of 1.6 to 1.8 km from the array. Modeling of a single seismic source in a water depth of 20 m predicted that levels near the water surface could be up to 10 dB lower. McCauley et al. (2000) stated that there was a possible bias in sighting rates based on a tendency for whales to utilize the sound shadow near the sea surface in order to reduce the RLs of sounds from seismic sources. Therefore, it is possible that these propagation effects resulting in dramatically reduced received sound levels near the sea surface could explain the higher sighting rates at distances > 3 km when the seismic source was on.

In summary, results of the comprehensive study by McCauley et al. (2000) on the effects of seismic sources on behaviors of humpback whales concluded that (1) migrating whales near a 3D seismic vessel showed avoidance maneuvers at distances over 4 km away, so as not to allow the vessel to pass closer than 3 km; (2) groups containing resting females in certain habitat types were more sensitive and showed an avoidance response at an estimated distance of 7–12 km from a large seismic source; and (3) some males were attracted to single seismic sources.

Table 7-1: Summary of documented effects of seismic source operations on gray, bowhead and humpback whales.

Source	Received Level (dB re 1 µPa *rms*)	Species	Effects
Richardson et al. 1995	150-180	Gray and bowhead whales	General standoff range—summary of multiple study results
McCauley et al. 2000	157-164	Humpback whales	Standoff range for migrating humpbacks
McCauley et al. 2000	140	Humpback whales	Avoidance begins for resting groups with cows in key habitat type
McCauley et al. 2000	143	Humpback whales	Standoff range observed for resting groups with cows in key habitat type
McCauley et al. 2000	179	Humpback whales	Maximum level tolerated by investigating probable male humpbacks to single seismic source, although possibly due to visual clues

Adapted from "Marine seismic surveys – a study of environmental implications" by McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Australian Petroleum Production and Exploration Association Journal 2000:692-708.

Recently, Cerchio et al. (2014) deployed 2 MARUs between March and December 2008 off the coast of Northern Angola. They analyzed the number of singers and other variables using Generalized Additive Mixed Models (GAMMs) to test for the effect of seismic survey activity in the vicinity on the number of singing whales. Numbers of singers were counted during the first 10 min of every hr for the study period. They recorded relevant time and environmental variables (e.g., survey day, hr of day, moon phase) and RLs of seismic survey pulses. Model results indicated that the number of singers decreased significantly with increasing RLs of seismic survey pulses. This explanatory variable was included among the top-ranked models for 1 MARU in the full dataset and both MARUs in the reduced dataset. They believed that these results indicate that the breeding display of humpback whales is disrupted by seismic survey activity.

Fristrup et al. (2003) found that humpback whales increased their song length in response to the U.S. Navy's Low Frequency Active Sonar (LFAS) broadcasts. Two types of sonar pings were alternated: a ‛‛high frequency" ping of ~260–320 hertz (Hz) and a ‛‛low frequency'' ping of ~150–230 Hz. SL was a significant factor in humpback responses: higher SLs were associated with longer songs.

Risch et al. (2012) detected humpback whale song less often in their study area when Ocean Acoustic Waveguide Remote Sensing (OAWRS) signal transmissions were occurring than at other times. The RL of OAWRS pulses approximately 200 km from the source array were 5–22 dB above ambient noise levels. Thus, in response to OAWRS FM pulses, with relatively low sound exposure, male humpback whales either moved out of the study area or sang less (Risch et al. 2012).

Moulton and Holst (2010) found that the average distance of the initial observation of humpback whales from the seismic vessel was significantly greater (mean = 2,827 m) when the full seismic source array was operating compared to periods when any other seismic source configurations were operating (including single sources and source ramp-ups) (mean = 2,604 m) and when no seismic sources were operating (mean = 2,381 m). In addition, humpback whales were significantly more likely to swim away, less likely to swim towards and exhibit milling behavior when the full array operated versus when no seismic source was operating (Moulton and Holst 2010).

Overall, available studies indicate that the most commonly expected behavioral response by humpback whales to seismic sounds is short-term and localized movement away/displacement from active seismic operations, and possibly changes in calling behavior. There is some indication that females may be more sensitive, resulting in a slightly larger avoidance radius and males may, on rare occasion, approach the operations. Exposures of humpback whales to proposed seismic operations are likely to be limited to spring, fall and winter when this species is most likely to migrate through generally offshore deeper waters. However, implementation of the proposed 4MP including shut down and ramp up measures, will minimize potential exposure to whales that may approach or occur within the EZ.

7.1.2 Toothed Whales (Odontocetes)

Available data on the responses of toothed whales and dolphins to seismic noise indicate that similar to baleen whales, responses vary with species, behavior, and context, as described below. All of the documented responses are limited to short-term behavioral responses with no known long-term significant effects. Seismic source energy is mostly concentrated in lower frequencies (e.g., < 500 Hz; Potter et al. 2007). However, seismic sources also produce incidental high-frequency energy (20-100 kHz). Thus, these higher frequencies may affect odontocetes (Goold and Fish 1998; Bain and Williams 2006) that rely on high frequencies to communicate, echolocate, and listen to their environment.

Earlier studies in the Gulf of Mexico (GoM) fielded to find relationships between the presence of seismic noise and distribution of cetaceans on the relatively large spatial scale of hundreds of km (Rankin and Evans 1998). However, more recent information indicates that at least 1 species, the harbor porpoise, responded to seismic surveys up to 70 km away (Bain and Williams 2006). Recently, several studies have been conducted to examine compiled responses of odontocetes to multiple seismic surveys in more detail. Some have involved monitoring odontocetes from the seismic vessel or another vessel located close to it (Moulton and Miller 2005; Bain and Williams 2006; Stone and Tasker 2006; Potter et al. 2007; Weir 2008a,b). A multi-year, multi-methods study was conducted on the effects of seismic surveys on sperm whales in the GoM, providing a useful longitudinal perspective on a single species (Jochens et al. 2008).

Dolphins and porpoises have been observed in close proximity to active seismic vessels, including bow riding (Moulton and Miller 2005). However, Goold and Fish (1998) found that dolphins approached the guard boat relatively infrequently during the seismic survey, especially when the seismic source was active. They suggested that the seismic source was a disturbance within a limited radius. Localized avoidance by delphinids has also been reported by Gordon et al. (2004), Stone and Tasker (2006), and Weir (2008a,b), among others. In most cases, avoidance radii appear to be relatively small.

Recent analyses of marine mammal sightings and behaviors observed during seismic surveys have resulted in some important and useful information on odontocetes based on relatively large sample sizes (Stone 2003; Stone and Tasker 2006; Moulton and Holst 2010). Stone and Tasker (2006) examined sighting rates, distance from the seismic source, and orientation of animals during seismic surveys off the UK and adjacent waters. They analyzed data from periods when the seismic source was active and when it was inactive, and for surveys with large- and small- volume seismic sources. Small odontocetes showed the strongest horizontal avoidance (extending at least as far as the limit of visual observation) in response to active seismic sources. Responses to active seismic sources were greater during seismic surveys using large-volume seismic source arrays than those using smaller-volume seismic source arrays. In general, most species also were sighted further away during active versus inactive periods of seismic source activity. Moulton and Holst (2010) also found that initial detection distances for delphinids were significantly farther during seismic-on (by approximately 200 m) versus seismic-off periods; however, there was no significant difference for sighting rates when the seismic source was on versus off. For large-toothed whales (sperm whales and beaked whales) sighting rates and distances were closer to the seismic source when it was on versus off.

Effects of noise on hearing have been studied more for odontocetes than baleen whales due to the ability to study the smaller-sized dolphins in captivity. Numerous such captive studies have investigated TTS caused by tonal sounds or broadband noise among bottlenose dolphins and beluga whales (e.g., Nachtigall et al. 2003, 2004; Schlundt et al. 2000; Finneran et al. 2005; Mooney et al. 2009). However, only two published studies have measured TTS responses to seismic source-like noise in odontocetes (Finneran et al. 2002; Lucke et al. 2009). The first reported a TTS onset level of 186 dB re 1 μPa2 - s in response to pulses from a seismic source for a captive beluga whale. In the same study, bottlenose dolphins did not exhibit a TTS in response to a maximum level of 188 dB re 1 μPa2 - s (Finneran et al. 2002). In the second study, a harbor porpoise showed a much lower TTS onset level of 164 dB re 1 μPa2 - s in response to pulses from a seismic source (Lucke et al. 2009).

Overall, as summarized below by odontocete species and/or taxa, documented responses of odontocetes to seismic activities are varied. Similar to mysticetes, the type and level or sensitivity of response appears to be related to behavioral state (e.g., feeding, resting, migrating, bowriding) as well noise/exposure characteristics (SL, playback versus actual source, distance to source, etc.). Hearing sensitivity is also expected to play a role, with those odontocetes with good low-frequency hearing (e.g., the larger ones) (Southall et al. 2007) assumed to be most sensitive to the low-frequency energy components that characterizes seismic source noise. For the smaller odontocetes peak hearing sensitivity is centered on mid- to high-frequencies (e.g., Richardson et al. 1995; Southall et al. 2007). Thus, they are generally considered to be less sensitive to seismic noise.

Field studies indicate that anticipated responses are limited to short-term behavioral changes (including changing or temporarily increasing call patterns) and/or localized displacement/movement away from the seismic activity; however, some individuals may approach and even bow ride an active seismic vessel, as described below. Although TTS has been documented for a few species odontocetes in controlled/experimental studies of captive animals (e.g., Finneran et al. 2010a, 2010b, 2007, 2005; Mooney et al. 2009), free-ranging individuals may have options to reduce or eliminate the possibility of TTS. For example, they are able to move away from the source well before TTS onset might occur. Collecting more data on distances at which animals avoid seismic source arrays will provide important information to allow a better understanding about what RLs animals react or take actions to reduce the likelihood of TTS and PTS. Implementation of mitigation and monitoring measures as proposed in the project 4MP are expected (e.g., ramp-up procedures and monitoring the EZ) should reduce potential exposure of odontocetes to seismic noise within the EZ that could result in TTS.

7.1.2.1 Sperm Whale

Sperm whales are considered to have better low-frequency hearing than smaller odontocetes, and therefore may be more susceptible to behavioral disturbances from seismic operations (Gordon et al. 2004). Earlier studies reported that sperm whales decreased their vocalization rates (Bowles et al. 1994) redistributed or left the area during a seismic survey (Mate et al. 1994; Stone 2006). However, results from more recent studies indicate little evidence of such reactions or inconsistent effects (Swift 1998; Miller et al. 2009).

One of the most detailed studies on continuous behavior of an odontocete exposed to seismic noise was conducted in the GoM where 8 sperm whales were equipped with multi-sensor datalogger tags (i.e., D–tags) (Miller et al. 2009). These tags recorded both movement of and sounds produced by the whales before, during and after controlled sound exposures to seismic sources; this included pitching effort (i.e., the rate and relative strength of fluking motions) to provide an index of each whale’s relative locomotion effort. Results were as follows:

1. Tagged whales did not display horizontal avoidance of the seismic vessel at distances of 1 to 13 km;
2. Foraging whales continued to forage when seismic sound started and continued to forage throughout seismic operations;
3. Foraging whales had lower pitching effort and lower mean buzz rates during seismic operations, suggesting that they expended less energy foraging or fewer feeding events occurred during exposure;
4. One non-foraging tagged whale continued resting when seismic sound started; this whale rested for an atypically long bout throughout the entire operation and became active only after the seismic source was stopped.

It was suggested that seismic operations may have caused this animal to delay diving deeply to forage (although this was based on a sample size of 1 animal/one event). It should also be noted that this population of whales was not naïve to exposure of seismic sources and may have become habituated at some level to this type of noise.

Off eastern Canada, sighting rates and distances to sperm whales were similar during seismic-on versus seismic-off periods (Moulton and Holst 2010). The latter results were based on analysis of sighting and behavioral data collected by experienced observers during

8 seismic surveys. Similarly, Stone and Tasker (2006) reported that seismic operations did not result in any significant differences in orientation, sighting rate, or sighting distances for sperm whales based on data collected during 201 seismic surveys.

A study by Madsen et al. (2002) off Norway reported that sperms whales did not change their vocalization rates when exposed to distant seismic sounds from over 20 km away. Estimated maximum sound pressure received at the location of the whales was approximately 146 dB re 1 μPa (pk-pk) or 124 dB re 1 μPa 2s (in terms of energy). The exposure to the seismic survey pulses did not elicit observable avoidance as the whales stayed in the area for at least 13 days of exposure. Madsen et al. (2002) found that sperm whales did not avoid the area during the seismic operations and did not change their vocal patterns during foraging dives.

Based on the above studies and other available data on odontocete behavior near seismic operations, the proposed seismic survey could result in some short-term behavioral reactions by sperm whales, including behavioral avoidance and changes in echolocation behavior. Exposures of sperm whales during proposed seismic operations would likely be limited to the mid-Atlantic Planning Area region during fall, winter and spring when this species is most likely to occur in deep offshore waters of the survey area. Potential project-related effects would be reduced with implementation of mitigation measures as well as the 4MP (see Section 11). No significant impacts to the population are anticipated given available studies of sperm whales and reviews of seismic impacts on other odontocete species.

7.1.2.2 Beaked Whales

There have been few directed studies on the effects of seismic survey activity on beaked whales. As previously mentioned, seismic surveys have been potentially implicated in 2 separate beaked whale stranding events (Gentry 2002; Taylor et al. 2004 detailed below in section 7.4); however, the exact causal factors resulting in these stranding events remains unclear so a direct connection could not be proven.

There have only been a few studies that analyzed marine mammal observer data collected during mitigation efforts for various seismic surveys. Moulton and Miller (2005) analyzed marine mammal observer data collected during over 900 hr and 10,000 km of seismic surveys conducted on the Scotian Shelf near the marine protected area known as 'The Gully'. They recorded only 1 group of 4 male northern bottlenose whales when seismic sources were not operating during a turn. There were no sightings when the seismic source was active. After compiling data from 8 seismic surveys off eastern Canada, Moulton and Holst (2010) reported that beaked whales did not respond overtly to seismic noise.

Gosselin and Lawson (2004) conducted vessel-based line- transect surveys in the Gully before and during seismic operations and over an area of 1,851 km^2 covering 2 adjacent marine canyons only before seismic activities. These surveys indicated that northern bottlenose whales were present in the Gully when exposed to received seismic sound levels up to 145 dB re 1 μPa (rms). However, these visual surveys were conducted while seismic surveys were being conducted at the most distant region of the survey area relative to the Gully. Similarly, passive acoustic studies in the same study area using data from autonomous recorders and ocean bottom seismometers indicated that some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from seismic surveys conducted 30 to 150 km away (Simard et al. 2005; Laurinolli and Cochrane 2005).

Results from multiple studies indicate that beaked whales respond adversely to other sources of anthropogenic sounds such as Navy sonar and vessel noise. Documented responses to Naval sonar include stranding, swimming away from the sound source, changes in diving, foraging, and vocalizing behaviors, and remaining at depth, or at the water surface longer than average (Cox et al. 2006). Recently, numerous studies have investigated behavioral responses of beaked whales to MFAS. For example, the distribution of Blainville's beaked whales was analyzed at the U.S. Navy Atlantic Undersea Test and Evaluation Center (AUTEC) range, in the Bahamas, before, during, and after transmissions of MFAS from multiple sources (McCarthy et al. 2011). Vocal activity declined during active sonar exercises and increased when the exercises stopped. McCarthy et al. (2011) interpreted this as either an avoidance reaction (i.e., animals moved out of the area) or a cessation of vocalizations during MFAS production.

At the same range, Tyack et al. (2011) reported similar results for Blainville's beaked whales exposed to both real and simulated MFAS events (i.e., MFAS playback) (Tyack et al. 2011). In the latter study, researcher's analyzed data collected with a seafloor hydrophone array and from multi-sensor electronic tags (i.e., D-tags) attached directly to animals. The beaked whales monitored and tracked in this study stopped echolocating and moved away from the sound source during both MFAS exposure conditions. Tagged animals moved tens of km away during the sonar operations and slowly returned to the area after operations stopped. In addition, beaked whale clicks were detected inside the AUTEC range before and after sonar exercises, but were detected only on the periphery of the range during sonar operations (based on the seafloor hydrophone array data). Based primarily on the results of these studies, researchers have proposed a mechanism to link stranding events to MFAS in which an acoustically induced, behavioral flight response to MFAS (i.e., animals flee from the source) elicits extended bouts of shallow dives which leads to gas bubble formation, and ultimately results in stranding (Tyack et al. 2006; Cox et al. 2006).

These studies focused on the effects of MFAS on beaked whales. Similar studies have not been conducted with beaked whales in relation to seismic sources; therefore, it is unknown whether beaked whales exposed to seismic operations would react similarly. Although it appears that beaked whales are sensitive to some types of intense, periodic sources of sound, particularly MFAS, seismic sources have very different sound characteristics (as reviewed in Richardson et al. 1995 and Southall et al. 2007); therefore, it cannot be assumed that beaked whales will respond in a similar manner.

Based on the limited information available that specifically relates to seismic survey noise, some beaked whales may be expected to exhibit behavioral responses to seismic sounds, but depending on the species and circumstances, some animals may remain in the areas if they are important for foraging or other essential biological activities. Short-term changes in behavior including localized avoidance/displacement, changes in diving behaviors, and possibly disrupted foraging behaviors may occur. Given the information available from the studies on beaked whales reviewed above, no significant impacts to beaked whale populations are anticipated as a result of the proposed seismic survey.

7.1.2.3 Killer Whale

Killer whales have been reported to exhibit avoidance of seismic vessels and other high-amplitude sound sources, though very few data are available near seismic operations. Based on analysis of marine mammal sighting data collected during 201 seismic surveys off the UK and adjacent waters, Stone and Tasker (2006) reported greater sighting distances for killer whales while seismic sources were on versus off indicating some level of spatial avoidance. Stone (2003) hypothesized that killer whales may be more tolerant of seismic activity in deeper waters. Off British Columbia, Canada, Morton and Symonds (2002) associated the use of acoustic harassment devices (AHDs) over 7 years with significantly lower killer whale occurrence compared to the 7 years after the AHDs were removed. In contrast to the results of these studies, no effects on killer whales were evident from noise from small explosive charges based on a review of several studies by Jefferson and Curry (1994).

In summary, it is likely that killer whales would exhibit short-term, localized behavioral avoidance of the proposed seismic operations.

7.1.2.4 *Pilot Whale*

Pilot whales have been reported to show avoidance behaviors in the presence of seismic sound sources. Pilot whales present during a seismic operation off Angola showed a limited avoidance response to the ramp up of a large seismic source array (Weir 2008b). In a study describing marine mammal visual and acoustic observations made during the Heard Island Feasibility Test, Bowles et al. (1994) reported that pilot whales were not heard or sighted during the transmissions, but were heard and sighted both before and after transmissions. During 8 seismic surveys that included vessel-based monitoring in the waters off eastern Canada, pilot whales were initially sighted farther from the seismic vessel when the seismic source was operating versus when it was not operating (Moulton and Holst 2010).

In summary, similar to other delphinid species, some pilot whales are anticipated to exhibit short-term localized avoidance and movement away from the proposed seismic source, and may also change their calling patterns.

7.1.2.5 Short-Beaked Common Dolphin

In the Irish Sea, short-beaked common dolphins were visually observed generally moving away from a 2D seismic source vessel, with the majority of sightings occurring while the seismic source was silent (Goold 1996). Off eastern Canada, common dolphins were sighted further from the seismic vessel when the seismic source was active versus inactive, based on visual monitoring observations made during 8 seismic surveys (Moulton and Holst 2010). The available information indicates that common dolphins are anticipated to respond to proposed seismic operations by temporarily changing their behavior by moving away from a localized area near the operating seismic vessel.

Based on the above studies and other available data on odontocete behavior near seismic operations, the proposed seismic survey could result in some short-term behavioral reactions by common dolphin.

7.1.2.6 Pantropical Spotted Dolphin

Reports of pantropical spotted dolphins near seismic operations are very limited. Gray and Van Waerebeek (2011) described an apparent mortality of a single pantropical spotted dolphin that they attributed to close exposure to a 3D seismic survey operating with a seismic source array volume of 2 x 3,400 in^3 towed at a water depth of about 6 m off Liberia, Africa. An adult pantropical spotted dolphin was initially observed 600 m ahead of the seismic source array. The dolphin did not move away from the seismic vessel but instead exhibited what they described as aberrant behavior, exposing its rostrum, head and cervical region above the water surface, appearing rigid. The authors suggested that this behavior was a possible attempt by the dolphin to shield its sensitive hearing structures and rostrum from the intense acoustic energy of the operating seismic source. Gray and Van Waerebeek (2011) proposed that the dolphin suffered severe "acoustic distress if not internal injuries". It eventually stopped moving, sank and was not resighted as the seismic vessel continued on its course. The authors presumed that the dolphin likely died of asphyxiation. They further suggested a cause-effect relationship with the seismic survey based on the close spatial and temporal association between the dolphin's behavior and the operating seismic source array.

In summary, limited species-specific observations on pantropical spotted dolphins near seismic operations indicate that individuals are anticipated to move away from the proposed operating seismic source.

7.1.2.7 Atlantic Spotted Dolphin

Atlantic spotted dolphins present during a seismic operation off Angola showed short-term and localized displacement in response to operation of the seismic source array (Weir 2008a). Dolphin distances from the vessel were significantly greater when the seismic source was on versus off. When the seismic source was silent all sightings were within 500 m, but when seismic sources were operating no dolphins were seen within 500 m.

Thus, similar to other delphinid species, some Atlantic spotted dolphins are anticipated to exhibit short-term localized avoidance and movement away from the proposed seismic source.

7.1.2.8 Harbor Porpoise

Harbor porpoises have exhibited avoidance behaviors in response to seismic sounds in two primary studies. Based on visual observations during a seismic survey off British Columbia and Washington, animals moved away from a seismic source at RLs as low as 145 dB from sources as far away as 70 km (Bain and Williams 2006). Stone and Tasker (2006) reported that mean sighting distances were greater for harbor porpoises while the seismic source was active versus when the source was inactive, based on analysis of visual sighting data from 201 seismic surveys. In another study using controlled experiments with a captive harbor porpoise, avoidance behaviors were recorded in response to RLs above 174 dB re 1 μPa pk-pk (168 dB re 1 μPa peak), and a SEL of 145 dB re 1 μPa2 - s (Lucke et al. 2009).

In summary, the available information suggests that proposed seismic operations could result in temporary avoidance responses by harbor porpoises but would not be expected to result in any population-level effects.

7.1.3 Seals

Seals are expected to show little or no avoidance reaction to seismic activities involving operation of a seismic source based on available data. Typically, seals may show an initial reaction to loud noises, but generally do not react to noises from a seismic source. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of a seismic source by pinnipeds, and only slight (if any) changes in behavior (LGL 2011). In the Puget Sound, sighting distances for harbor seals tended to be farther when a seismic source array was operating (Calambokidis and Osmek 1998; LGL 2011). Previous telemetry work suggests that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998; LGL 2011). Only short-term and temporary displacement should occur as a result of the proposed survey. Seals are not likely to be exposed to source levels of over 190 dB re 1 µPa given proposed mitigation measures.

7.2 Hearing Impairments

7.2.1 Temporary Threshold Shift and Permanent Threshold Shift

Hearing impairments such as temporary or permanent loss of hearing sensitivity can be caused by intense sounds due to their high sound SLs. These physiological and anatomical impacts can have negative effects on marine mammals, resulting in the inability to detect important sounds (e.g., communication or echolocation signals) in their environment.

The minimum sound level an animal can hear at a specific frequency is known as the hearing threshold at that frequency. Sounds above a hearing threshold will have no deleterious effects until a certain level of sound intensity or duration is reached. Too much exposure above this level will cause a shift in the hearing thresholds. Following exposure, the magnitude of the hearing impairment, or threshold shift, normally decreases over time after exposure to the noise ends.

The two main types of hearing loss are temporary threshold shifts (TTS) and permanent threshold shifts (PTS). TTS is the mildest form of hearing impairment that can occur during exposure to an intense sound (Kryter 1994; LGL 2012). When TTS occurs, hearing sensitivity is temporarily reduced; however, this reduction is usually reversible. Short-term, negative effects resulting from TTS may include an animal being unable to locate predators or prey, or communicate effectively with other individuals. Chronic exposure to less-intense sounds that result in recurring TTS can eventually result in PTS. As the name implies, PTS is a permanent condition in which the hearing sensitivity threshold is elevated permanently (i.e., it does not return to the original level). Exposure to a single or a few very intense sounds (or periods of intense sound) has the potential to cause irreversible hearing damage and PTS.

Several important factors relate to the type and magnitude of hearing loss, including exposure level, frequency content, duration, and temporal pattern of exposure relative to the hearing sensitivity of the animal. A range of mechanical effects (e.g., stress or damage to supporting cell structure, fatigue) and metabolic processes (e.g., inner ear hair cell metabolism such as energy production, protein synthesis, and ion transport) within the auditory system underlie both TTS and PTS. Southall et al. (2007) provides additional detailed discussion of TTS and PTS.

TTS and PTS for any given species depend on the hearing sensitivity of that species. Finneran et al. (2002) estimated that exposure to received sound levels above 192 dB re 1 μPa will lead to a TTS in most cetaceans (NMFS 2005a). There are no data identifying the level of sound intensity that causes a TTS in baleen whales. However, because most baleen whales show avoidance at certain sound intensities, TTS is unlikely to occur (Minerals Management Service [MMS] 2006; Southall et al. 2007).

Under prolonged exposure, pinnipeds have been shown to exhibit TTS. Kastak et al. (1999) investigated the effects of noise on 2 California sea lions, 1 northern elephant seal and 1 harbor seal. They subjected each pinniped to a noise source (at frequency 100 to 2,000 Hz) for 20 to 22 min. Each pinniped showed a threshold shift averaging 4.8 dB (harbor seal), 4.9 dB (sea lion), and 4.6 dB (northern elephant seal). The hearing threshold returned to pre-exposure values within 12 hr.

The effects of noise exposure and threshold shifts are well understood for humans and terrestrial mammals (Kryter 1985, 1994), and over the past fifteen years have been investigated in several species of marine mammals (e.g., Kastak et al. 1999; Finneran et al. 2000, 2003). However, due to the difficulties of studying these effects in free-ranging animals, almost all studies have been conducted on captive odontocetes and pinnipeds (Kastak et al. 2005; Finneran et al. 2007; Southall et al. 2007; Lucke et al. 2009; Kastelein 2012a,b), or based on physiological effects seen in dead animals (Ketten et al. 1992, 2000).

No data for TTS or PTS exist for free-ranging baleen whales or sperm whales. However, Gedamke et al. (2011) modeled the effect of individual variability and uncertainty on risk assessment of baleen whale TTS for seismic surveys. In the modeled base scenario, 29 percent of whales that approached within a 1–1.2 km range of the seismic source were exposed to sound levels sufficient for TTS onset. By comparison, no whales were at risk outside 0.6 km when uncertainty and variability were not considered. Potential "exposure altering" parameters (movement, avoidance, surfacing, and effective quiet) were also simulated. Although Gedamke et al. (2011) recommended more research to refine the model inputs, the results indicated that whales located 1 km or more from the modeled seismic survey could still potentially be susceptible to TTS once the large impact that uncertainty and variability can have on risk assessment is accounted for.

Based on conclusions reached by the High Energy Seismic Survey (HESS) (1999), NMFS established a 180 dB re 1 μPa (RL) threshold criterion for injury from sound exposure for cetaceans, and a 190 dB re 1 μPa threshold criterion for pinnipeds. Calculated radial distances to the 180-dB isopleth are dependent upon the size and orientation of the array and physical characteristics of the marine environment and sediments (e.g., water column stratification, water depth and nature of the seafloor). These criteria have been used by NMFS as the standards against which to assess potential "Level A" take (i.e., risk of TTS or PTS) and require mitigation and monitoring (65 FR 16374; Southall et al. 2007).

When conducting the proposed seismic activities, TTS or PTS are not expected to occur in marine mammals. Mitigation measures such as monitoring by PSOs within the EZ, ramp-up prior to seismic operations, and shutdowns combined with anticipated behavioral avoidance of loud sounds (based on numerous studies) are expected to significantly reduce the possibility of exposure of marine mammals to SELs from seismic sources that could cause TTS and PTS.

7.2.2 Masking

Another potential negative impact of seismic sounds on marine mammals is auditory masking. Masking can be described as a phenomenon in which a given signal cannot be detected or discriminated by a receiver because a stronger sound of a similar frequency, or frequency band, interferes with the original signal (Richardson et al. 1995). Generally, noise will only mask a signal if the frequencies of both sounds are similar (Gordon et al. 2004). Elevated background noise levels caused by man-made noise may prevent detection of other sounds important to marine mammals. Spectral, temporal, and spatial overlap between the masking noise and the sender/receiver determines the extent of masking: the greater the spectral and temporal overlap the greater the potential for masking.

The spectra of low-frequency sounds produced by a seismic source overlaps with spectra of calls by many species of baleen whales and walruses, but not as closely with frequencies used by odontocetes and most pinnipeds. The smaller odontocetes (e.g., delphinids) communicate and echolocate using peak frequencies that are much higher than the peak spectra produced by a seismic source, therefore, their signals will be masked to a smaller degree than sounds produced by baleen whales. The ability of whales and dolphins to circumvent the effects of masking is not well understood in free-ranging animals, but is likely they have some mechanisms (i.e., behavioral or psychophysical) to compensate for masking such as redundancy or repetition of their signals (for callers) and orientating towards incoming sounds (for receivers).

There are several studies that indicate baleen and toothed whales continue calling in the presence of seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999a,b; Nieukirk et al. 2004; Smultea et al. 2004; Holst et al. 2005a,b, 2006; Dunn and Hernandez 2009). During 13 days of seismic surveys, sperm whales continued clicking, and vocalization patterns remained undisturbed by received noise levels up to 146 dB re 1 μPa (Madsen et al. 2002). In some cases, changes in calls have been interpreted as a means to compensate for interference of the seismic noise with the animal's calls. In other cases, marine mammals have been reported to reduce or stop calling during seismic operations. More detailed examples are provided below.

Recently, Clark et al. (2009) modeled the reduction in 'communication space' of singing humpback whales, singing fin whales, and calling right whales caused by masking by ship noise. They did this by using a combination of modeling and analytical techniques, the sonar equation, and empirical data to create time-varying spatial maps. These dynamic maps were used to demonstrate how noise from large ships can reduce the communication space (via masking) in these species of whales. The goal of this effort was to better elucidate connections between spatio-spectral-temporal variability in the ambient noise environment of a free-ranging animals, and subsequently, the loss of opportunities to communicate.

Similar reductions in communication space for baleen whales might be expected for noise produced by seismic surveys. However, it should be noted that noise from seismic sources is periodic in nature (i.e., it is regularly spaced with periods of several sounds of silence in-between the seismic pulses), compared to the continuous type of shipping noise modeled by Clark et al. (2009).

Sound sources used during seismic activities have the potential to mask marine mammal communication and detection of environmental cues if an individual is present within audible range of seismic survey sound sources. The focus of sound energy from seismic sources is directed downwards towards the seafloor, however, some energy is always is directed, or propagates horizontally from the sources which could result in masking. Low-frequency sound from seismic sources and vessel noise primarily overlaps with vocalizations from baleen whales, and the larger odontocetes such as sperm whales and killer whales, pilot whales, Risso's dolphins and false-killer whales. Seismic survey protocols and mitigation procedures (described in Section 11) would be implemented to decrease the potential for any marine mammal(s) to occur within the EZ of operating seismic source arrays and thus would presumably also reduce potential effects of masking, although they cannot be eliminated.

7.3 Tolerance

In one of the few multi-species field studies on the effects of seismic surveys on marine mammals, Stone and Tasker (2006) found that some species of cetaceans are disturbed by seismic exploration while others are not. Their analysis was based on observations of cetaceans made during approximately 200 seismic surveys off the UK. They compared sighting rates, distance from the seismic source and orientation for periods when seismic sources were active and non-active, both for surveys with large volume seismic arrays and surveys with smaller volume arrays. Small odontocetes showed the greatest spatial avoidance in response to active seismic sources, extending at least to the limit of visual observation. Mysticetes and killer whales showed more localized spatial avoidance. Long-finned pilot whales showed only changes in orientation. There were no statistically significant effects detected for sperm whales.

Overall, responses to active seismic sources were greater during seismic surveys using large volume seismic arrays than for surveys using small volume seismic arrays. During seismic operations, fewer animals appeared to feed, smaller odontocetes appeared to swim faster, and mysticetes remained longer at the surface (a region where sound levels were expected to be lower – see the humpback whale Section 7.1.1.6 above for a detailed explanation). Stone and Tasker (2006) suggested that the different species of cetaceans may adopt different strategies for responding to sound exposure from seismic surveys. For example, some small odontocetes typically move out of the immediate area, while slower-moving mysticetes orient away from the vessel and increase their distance from the source but do not vacate the area.

7.4 Stranding and Mortality

There have been no confirmed physical injury or deaths directly attributed to marine mammals from exposure to the proposed active acoustic sound source, or other seismic sources (BOEM 2014a). However, seismic operations have been proposed or presumed as an explanation for some unusual behavioral, stranding and 1 death events that have occurred concurrently to or immediately following seismic source surveys (Anonymous 2001, Gentry 2002; Gordon et al. 2004; Taylor et al. 2004). In one case, a single pantropical spotted dolphin appeared to exhibit aberrant behavior 600 m ahead of a 3D seismic source operating at sea off east Africa, after which it was presumed to have died (though death was not confirmed) (Gray and Van Waerebeek 2011, see Section 7.1.2.6). The animal exposed its head and cervical area above the water surface in an apparent rigid posture for 5 min (Gray and Van Waerebeek 2011). It then sank below the surface and was not seen again as the seismic vessel moved past and away from the dolphin's last-observed location. The authors concluded it was likely that the seismic exposure was responsible for the animal's death, as they presumed that it died after sinking. The authors implicated seismic noise as the probable cause of the presumed death given the close spatial and temporal correlation between the dolphin's behavior and the 3D seismic operations (Gray and Van Waerebeek 2011).

In another event in 2002, a stranding of 2 beaked whales in the lower Gulf of California was reported to several senior NOAA marine mammal scientists who were in the area. The scientists later became aware that a geo-seismic survey was being conducted approximately 22 km away by Lamont Doherty's *R/V Maurice Ewing* (Taylor et al. 2004; Peterson 2003). Although there was no direct causal link established for the Gulf of California event, there was sufficient concern for a U.S. federal court to issue a restraining order until a more complete investigation could be completed (Malakoff 2003). This same vessel was conducting seismic surveys near the Galapagos Islands in 2000, when another beaked whale stranding event consisting of 3-4 animals occurred on Isla Santa Cruz, the Galapagos National Park (Gentry 2002). However, the cause was stated in the report as 'indeterminate' because the stranding occurred several hundred km away and there was no obvious mechanism to bridge the distance between the seismic source and the stranding site. Other stranding events have been related to use of a 12 kHz multi-beam echosounder during surveys by the oil and gas industry off Madagascar, but in that case a direct causal link could neither be confirmed nor refuted (Southall et al. 2013).

Effects of seismic surveys on marine mammals have not been investigated to the degree that they have for underwater explosions and military sonar. Injury and death of marine mammals have been observed in association with high-intensity underwater explosions that can result in lethal damage to internal organs or air-filled body cavities (e.g., lungs) (Yelverton et al. 1973; Goertner 1982; Young 1991; Danil and St. Leger 2011). Data on physical injury or physiological damage due directly to seismic source signals are limited to anecdotal or forensic investigations after events occurred. However, post-mortem examination indicate that marine mammals can be susceptible to direct physical effects following exposure to intense sounds such explosions, particularly where high-particle motion events occur. This includes evidence based on post-mortem examination of stranded humpback whales that had been feeding near sites of explosions and subsequently stranded

(Todd et al. 1996) combined with modeling based on impact data for the human vestibular system and lungs for underwater explosions (Cudahy and Ellison 2002).

With respect to military sonar, numerous investigations on the relationship between such sonar and marine mammal strandings have concluded there are links between the two (Cox et al. 2006; Tyack et al. 2006). Some beaked whale stranding events have been attributed to naval mid-frequency sonar activities via several mechanisms and processes (Jepson et al. 2003, 2005; Fernández et al. 2005; Cox et al. 2006; Tyack et al. 2006). There is growing consensus that exposure to military sonar, in some circumstances, can trigger a series of behavioral reactions in beaked whales (i.e., changes their normal diving behaviors) that can lead to physiological effects, injuries and, in some cases, even lethal stranding events (Tyack et al. 2011).

In summary, circumstantial evidence has linked exposure to large seismic source operations temporally and/or spatially to a few cases of unusual cetacean behaviors or stranding events. However, lethal impacts directly related to exposure to seismic source operations have not been proven as the cause. Due to the detailed and timely information that is needed to prove such a link, establishing a conclusive relationship between seismic source activity and lethal events is, understandably, difficult. There have been reports of other noise sources such as underwater explosions and mid-frequency sonar events that have been related to cetacean stranding events. It should be noted that seismic source pulses and mid-frequency sonar pulses have very different acoustic characteristics. Sounds produced by seismic source arrays are broadband with most of the energy concentrated below 1 kHz. In contrast, military mid-frequency sonar systems typically produce signals with frequencies ranging from 2–10 kHz, generally with a very narrow bandwidth (e.g., tonal sounds). Thus, it is not appropriate to assume the effects of military sonar and seismic surveys will be the same. The vast majority of observations of marine mammals near seismic operations indicate that responses are limited to short-term and localized behavioral avoidance or displacement at most (e.g., Stone and Tasker 2006; Moulton and Holst 2010).

Overall, given the available data and evidence, the proposed project is not anticipated to result in stranding or mortality of marine mammals, particularly given the planned implementation of the 4MP and associated mitigation and monitoring measures (see Section 13).

8 Anticipated Impacts on Subsistence

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

9 Anticipated Impacts on Habitat

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

The proposed 2D seismic program will not result in any permanent impacts on habitats used by marine mammals or their prey sources. Short-term project-related impacts consist of ensonification of marine waters by seismic project sounds as the seismic vessel travels at approximately 4-5 kt speed along survey lines. Such effects on the marine habitat would be short-term and transitional, and the sound habitat would be return to pre-survey conditions within a short period.

Limited studies indicate that exposure of vertebrate and invertebrate prey of marine mammals to seismic sounds can consist of direct mortality (pathological/physiological) within a few m of the operating sound source, and indirect (behavioral) effects on the movement of prey capable of active swimming (e.g., movement away from the source, short-term displacement). These effects on marine mammal prey would be negligible and insignificant relative to these populations and thus to marine mammal populations. The basis of this conclusion and information on the latter impacts to fish and invertebrates were addressed in detail in Sections 2 and Appendix J of the BOEM PEIS (BOEM 2014a).

Of the 39 species that have been documented in the MSA OCS BOEM AOI (BOEM 2014a), only the North Atlantic right whale has designated critical habitat within or near the proposed survey area. The North Atlantic right whale has designated critical habitat along the southern coast of Georgia to the northern coast of Florida, which represents the only known winter calving grounds of the this species in U.S. waters (Knowlton et al. 1992; Keller et al. 2006; Waring et al. 2013) (Figure 2-1). During the winter months, right whales are anticipated to concentrate off the southeastern U.S. This species is highly migratory, and spends a great deal of time moving between critical habitat in the southeastern states and feeding grounds off Cape Cod and Massachusetts Bay, Georges Bank, Great South Channel, Bay of Fundy and the Scotian shelf. With feeding occurring predominantly during summer months, migration peaks occur in the fall and spring (Knowlton et al. 1992; Firestone et al. 2008; Waring et al. 2013).

No direct or indirect impacts are expected to the important habitats specifically identified or protected for the North Atlantic right whale described above. The 160-dB project isopleth would also not temporal-spatially overlap important North Atlantic right whale habitats when this species is expected to occur there. Thus, seismic operations would not overlap in time and space with sensitive periods in designated critical habitat, SMAs (November 1 – April 30), DMAs, and Additional 20-nmi Closure Zones (November 1 – April 30) identified in the MSA OCA BOEM PEIS (BOEM 2014a) as important for North Atlantic right whales. Instead, proposed project activities would occur either (1) outside the project's estimated 160-dB seismic noise isopleth near these areas, and/or (2) in the latter areas during the summer and fall (April to October) when North Atlantic right whales would not be expected to occur or would occur in very low numbers within this portion of the survey area. Any project-related effects to habitat would be temporary and of short duration at any one place.

10 Anticipated Impact of Loss or Modification of Habitat on Marine Mammals

The anticipated impact of the loss or modification of the habitat on the marine mammal populations.

The anticipated impacts to marine mammal populations associated with temporary and transitional "modification" of marine habitat associated with elevated sound levels from the proposed moving seismic source array were discussed in detail earlier in Sections 6 and 7. Such effects are expected to be limited to shore-term localized impacts such as movement away, displacement, or behavioral changes. The effects of the planned seismic activity on food resources are expected to be negligible and insignificant at the population level for both marine mammal prey and marine mammals, as described in Section 9.

11 Mitigation Measures

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

WesternGeco proposes to implement procedures to minimize, mitigate and avoid potential adverse impacts on marine mammal species and stocks and their habitats as follows:

1. Implementing closure zone and period regulations and recommendations for marine mammals identified in the BOEM PEIS, Appendix C, Section 4.1 (BOEM 2014a) and finalized in the ROD (BOEM 2014b);
2. Conducting vessel-based monitoring (BOEM PEIS, Appendix C, Section 3.2.2 [BOEM 2014a]) with both visual and acoustic PAM PSOs on the seismic vessel;
3. Establishing and monitoring conservative EZs and DZs (i.e., based on SSV results for a larger-sized seismic source array than actually will be used by WesternGeco) by implementing
   - an EZ of 904 m (mean of the 21 modelled $R_{95\%}$ values modeled by JASCO in BOEM PEIS, Appendix D, Section 5 [BOEM 2014a]) for the full 5,085 in^3 array resulting in a power down to the 126 m EZ of the mitigation seismic source, if marine mammals occur within or closely approach this 904 m EZ, a full power down would not be required if delphinids voluntarily approach the vessel or the vessels towed equipment or
   - a full power down if a non-delphinid cetacean occurs within this 126 m EZ;
4. Implementing standard seismic source mitigation measures related to seismic operations (e.g., a 60 min "all clear" pre-ramp up, ramp-up, and shutdown periods) as directed in the BOEM Atlantic PEIS (BOEM 2014a) and ROD (BOEM 2014b);
5. Operating a single 105 in3 mitigation seismic source during turns and transits between seismic lines to continuously produce a small amount of sound into the environment to alert marine mammals of the presence of a sound source in the environment. If turns/transits are expected to take > 3 hr, the mitigation seismic source will be turned off per NMFS' suggestion (Ben Laws, pers. comm., May 2015—See Section 11.6.6) (most line changes/transits are approximately 4 hr, with some as many as 10 hr or more);
6. Increasing inter-pulse intervals of seismic transmissions to 60 sec while the mitigation seismic source is operating during turns and transits between seismic lines to reduce overall seismic noise (note this measure was approved by the NMFS Panel Review for TGS's seismic operations in the Chukchi Sea during late summer/fall 2013) (NMFS 2013);
7. Reducing the SL of the seismic array, using the same shot interval as the seismic survey, to maintain a minimum SL of 160 dB re 1 µPa m (rms) for the duration of operations during turns and transits between seismic (see condition 5 of PEIS Appendix C, Attachment 1 [BOEM 2014a]);
8. Implementing continual PAM with a towed hydrophone array deployed from the seismic vessel to complement visual monitoring and mitigation, particularly during periods of darkness and of low or no visibility/poor sighting conditions or when marine mammals are below the surface or beyond visual range.

It is important to distinguish between mitigation and monitoring as they have very different goals. In the context of seismic operations, mitigation represents the measures and protocols designed for and implemented during the seismic survey, specifically to eliminate or minimize potential impacts of operations on animals in the area exposed to sounds; monitoring is intended for collecting (usually longer-term) data both to assess short- and longer-term effects of seismic operations (modified from Nowacek et al. 2013).

The mitigation measures are described below in separate subsections. These subsections provide thorough information about the measures that are an essential part of the planned activities. Proposed procedures include vessel-based marine mammal monitoring, establishing and monitoring of EZs, and mitigation prior to and during seismic source operations. Proposed monitoring measures for marine mammals, including PAM, are described in Section 13.

11.2 Closure Zones and Periods

BOEM's PEIS and ROD requires limiting surveys using active acoustic sound sources during critical times within and in proximity to North Atlantic right whale calving and nursing habitat, migratory pathways, and when right whales are found aggregating in an area. These measures are meant to limit acoustic and vessel traffic disturbance and collision risk for North Atlantic right whales. The planned 2D seismic survey has been designed to minimize impacts to marine mammal species by implementing closure zones and periods identified in the BOEM PEIS (BOEM 2014a). WesternGeco proposes to follow these measures:

- No project seismic source operations would occur within the survey's maximum estimated 160 dB DZ distance from any designated right whale critical habitat area from November 15 through April 15, or within the mid-Atlantic and Southeast U.S. SMA south of Brunswick, Georgia (November 1 through April 30) (Figure 2-1, and Table A 1, Appendix A) and Additional 20 km Closure Zones North and South during the times when vessel speed restrictions are in effect (November 15 through April 15) from Delaware Bay to Wilmington, North Carolina and (November 1 through April 30) from offshore Florida adjacent to the North Atlantic right whale critical habitat between the Southeast U.S. SMA and the southern boundary of the AOI under the Right Whale Ship Strike Reduction Rule (50 CFR 224.105) (Silber et al. 2014) (BOEM 2014a, Appendix C, Section 4.1). All vessels will abide by the speed restrictions of 10 kt or less in SMAs and DMAs. Within DMAs all sound sources must cease within 24 hr of its designation (BOEM 2014b).
- No project seismic source operations would occur within the project's maximum estimated 160 dB DZ distance from active SMA or DMAs (areas where North Atlantic right whales are detected and no existing protective measure [s] are in place or in force) so as not to exceed the NMFS-designated Level B harassment threshold.

These time-area closures combined with proposed mitigation and monitoring measures are expected to significantly reduce the risk of impacts to North Atlantic right whales based on the Atlantic BOEM PEIS (BOEM 2014a) (Figure 2-1).

11.3 Vessel-based Visual Marine Mammal Mitigation

WesternGeco plans to conduct seismic operations 24-hr per day, including during nighttime. The main tasks of PSOs are to monitor the acoustic EZ for protected species and to observe and document their presence and behavior to reduce incidental takes of marine mammals via exposure to seismic sounds during proposed surveys. This information will provide real-time data necessary to implement some of the key mitigation measures as explained below. Three visual PSOs will be aboard each seismic vessel to rotate through daylight watch periods and to assist with PAM being conducted by acoustic PSOs during seismic periods and during periods of darkness/poor visibility.

Visual PSOs will monitor for marine mammals as follows:

- During all daytime (from civil twilight-dawn to civil twilight-dusk, 30 min before sunrise and 30 min after sunset) seismic source operations,
- During a minimum 60 min pre-ramp up clearance period,
- During ramp-up periods,
- After an extended (over 20 min) shutdown period,
- When there has been no mitigation source element in operation for a minimum of 60 min prior to initiation of the seismic source (i.e., ramp up) after an extended (over 20 min) shutdown period,
- During any nighttime start-up of the seismic source (unless nighttime vision is impaired or weather conditions make observations impossible) (e.g., Richardson 1998; Richardson and Lawson 2002; Smultea et al. 2004; Stone and Tasker 2006; Weir and Dolman 2007),
- During all daylight periods to the maximum extent practicable when no seismic activities are occurring (i.e., during transits and periods of seismic source silence exceeding 20 min but ending not < 60 min prior to next ramp-up).

When marine mammals are visually detected within or approaching the designated EZs (see Section 11.5 below), the seismic source will be powered down or shut down immediately (with the exception of dolphins approaching to bowride, for which no mitigation will be implemented as described in the BOEM Atlantic ROD [BOEM 2014b]). PSOs will communicate mitigation measures to the seismic source operators and vessel captain/crew within 1 source pulse period.

If a single seismic source or a seismic source array have been operational before visibility decreased or before nightfall, the seismic source operations may continue even though the entire EZ may not be visible. Visual PSOs will not be required to observe during extended periods of darkness due to the ineffectiveness of night vision devices (NVD) to observe marine mammals at distance (e.g., Richardson 1998; Richardson and Lawson 2002; Smultea et al. 2004; Weir and Dolman 2007). However, a PAM PSO operator will remain on duty during darkness (see the following subsection).

During darkness or other impaired visibility of the full EZ (e.g., poor weather), seismic operations may only commence:

- Without a ramp up if the shutdown period is < 20 min, and/or
- With a ramp up if PAM has been continuously operating with no detections of calling marine mammals determined to be within the EZ for a 60 min period immediately prior to ramp up.

In addition, the vessel captain/crew is to notify PSOs of any marine mammal observations during nighttime seismic operations.

Duties of PSOs monitoring from the seismic vessel will be to:

1. Document the occurrence of marine mammals within the survey area,
2. Assist in the implementation of required mitigation measures,
3. Record any potential reactions of marine mammals to the seismic operations.

On the seismic source vessel, 2 visual PSOs are proposed to simultaneously monitor for marine mammals within or approaching the EZ (except during short restroom [< 10 min] or meal breaks [< 30 min] when only 1 PSO will be on duty). The 2 observers will stand watch in a location that will not interfere with navigation or operation of the seismic vessel, while still providing an optimal view of the sea surface and a 360° view of the entire area around the seismic vessel; the latter is to ensure complete visual coverage of the EZ to the maximum extent practicable, given ongoing weather conditions. All visual PSOs will observe no more than 4 consecutive hr while on active watch for a maximum of 12 hr per day.

While on duty, each visual PSO will scan the area of operations for marine mammals alternating between using reticle binoculars (e.g., 7x50 Fujinon™) and the naked eye. One set of big-eye binoculars (25x150) will be used on the seismic vessel, with the 2 on-watch PSOs rotating through the big-eyes position to minimize eye fatigue. PSOs will use a laptop to record data, including species, group size/composition, location, distance from survey vessel, and behavior (and associated weather data). The proposed monitoring plan is described in greater detail in Section 13.

11.4 Passive Acoustic Mitigation

Per the BOEM ROD (BOEM 2014b), the use of PAM is required as part of the seismic source survey protocol. The purpose of PAM is to improve detection of marine mammals prior to and during seismic source surveys so that impacts can be avoided by shutting down or delaying startup of seismic source arrays until the animals are outside the EZ (BOEM 2014a). We propose to conduct real-time mitigation using a hydrophone array towed from the seismic vessel. Towed hydrophone arrays require a mobile a platform (e.g., a survey vessel or aircraft) to deploy, monitor, and operate them.

PAM will be used to supplement visual monitoring and other mitigation measures, during active seismic survey operations and during some non-seismic periods when possible. PAM will be the primary means of monitoring the EZ at night or when sighting conditions are poor. Three trained acoustic PSOs will be aboard each seismic vessel and will be assisted by PAM-trained visual PSOs as possible/as rotations allow. To prevent operator fatigue, no > 4 hr of continuous monitoring will be conducted by any single acoustic PSO at one time for a maximum total of 12 hr per 24-hr period. Acoustic PSOs will monitor during nighttime operations. One acoustic PSO will be monitoring at any given time. All acoustic PSOs will be proficient in PAM monitoring and operations and methods to localize vocalizing cetaceans. All operators will have received prior training via a qualified training course if they have less than 1 years' experience. To cover the proposed PAM periods and rotation limitations, a maximum of 3 acoustic PSOs are proposed to be located aboard the seismic vessel.

The type of PAM chosen for use was based on:

1. Mitigation and monitoring priorities (e.g., real-time mitigation and monitoring of the 180 dB EZ);
2. Availability and suitability of the monitoring platform (e.g., the type, number and operational priorities of project vessels) from which PAM could be deployed and operated;
3. Cost-effectiveness of the technology;
4. Reliability of the technology;
5. Effectiveness of the technology for detecting marine mammals, particularly ESA-listed species;
6. Suitability of the equipment for the environmental conditions, including water depth;
7. Relative abundance and distribution of species to be monitored;
8. Ability to detect species that cannot be easily or reliably detected by visual methods, especially elusive species and deep divers (e.g., sperm whales and beaked whales).

Based on the aforementioned considerations we selected real-time mitigation using a hydrophone array towed from the seismic vessel.

11.4.1 Towed Hydrophone Array Mitigation System (THAMS)

A Towed Hydrophone Array Mitigation System (THAMS) will be used to complement and supplement the visual mitigation program 24 hr per day. The THAMS will be the main method of mitigation when visual methods are not being used or are ineffective due to compromised viewing conditions (e.g., poor sighting conditions, low visibility, high Beaufort sea states, inclement weather such as rain, fog, or at night).

Another advantage of using a THAMS is that visual survey methods are not effective for detecting most deep-diving marine mammals such as sperm whales and beaked whales, nor are they effective for some visually elusive, but vocally active baleen whales, such as minke whales. Even when sighting conditions are good, PAM can be used to complement visual observations to improve detection, species identification, and localization of cetaceans. Towed hydrophone arrays are an ideal type of PAM to complement visual methods because they can be operated concurrently, or function as a stand-alone alternative for monitoring, such as at night (or in low -light conditions) when visual methods cannot be used (Zimmer 2011).

The THAMS will be deployed from the seismic vessel during all periods when the seismic source is operating and at least 60 min before operations commence to monitor the area for vocally active marine mammals. This system will be used to complement the visual mitigation program when PSOs are on effort, and as the primary means of mitigation when there are no PSOs on watch (e.g., at night or when conditions do not allow for visual monitoring effort of the full EZ to be conducted). PAM will occur in real-time by operators experienced in using the monitoring equipment and identifying calls of marine mammals in the survey area. Acoustic PSOs will alert visual observers when calling cetaceans are detected including bearing and distance information for these detections as possible.

The THAMS will consist of both hardware and software components to allow effective detection and localization of vocally active marine mammals. The hardware can be categorized simply as the "wet end" and "dry end" of the system. The wet end consists of components that are deployed into the water and remain wet during operation. This includes the hydrophone array connected to the dry end with a tow-cable. The two pairs of hydrophones will be separated approximately 200-400 m apart.

The separation distance of 1-3 m between the pairs of hydrophones will be used to allow for bearings to calling animals to be estimated to allow for localization of animals within the EZ (a maximum conservative radius of about 904 m). This design will also allow for Target Motion Analysis (TMA) (described in detail below). This localization method is the one most commonly used for line-transect surveys of marine mammals. A depth sensor will be included in the electronics tail section of the array to monitor the water depth of the hydrophone array. A typical towing depth range is at least 10-20 m, depending on the sound speed profile and survey vessel speed; however, this depth can be varied (by adding lead weight to the tail section) based on operating protocols and safety requirements of the seismic survey operations.

The "dry end" of the THAMS system consists of a deck cable that is used to connect the tow cable to the acoustic processing system and is located in a dry space, such as a computer room or a dry lab on the ship. The four-channel, analog signals from the hydrophone array will be filtered, digitized and processed using this system. All acoustic data from the PAM array are recorded to hard drives and backed up in real-time using a Redundant Array of Independent Disks (RAID) system.

One acoustic PSO will be on shift at a time, with a total of 3 acoustic PSOs rotating shifts over each 24-hr period, relieved for bathroom breaks and meals as needed. The acoustic PSO will monitor incoming signals, classify them to species, and localize signals whenever possible for individuals and groups. A second PAM system will be available as a backup, in case of equipment failure (see PAM monitoring plan below for details).

Localization of marine mammals using the THAMS will be accomplished using TMA. TMA is the simplest and most commonly used method of localization for research and mitigation (Leaper et al. 1992; Barlow and Taylor 2005; Norris et al. 2012). However, TMA requires certain assumptions to be met in order to work reliably. Using the TMA approach, bearings to a 'target' sound source are estimated by calculating the time delay between the same signal arriving at 2 closely spaced (a few m apart) hydrophones. If multiple bearings to the sound-producing source can be estimated over time, then at some point, these bearings will converge on the source's location (Figure 11-11). Due to the linear alignment of hydrophones, there is a left/right ambiguity that cannot be resolved without turning the vessel towing the hydrophones. The left/right ambiguity, however, is not a critical concern for mitigation during the WesternGeco 2D seismic survey if the array is co-located near the EZ. An important assumption of TMA is that the animals being monitored are stationary, or move relatively slowly with respect to the speed of the vessel towing the hydrophone array. Another assumption is that animals vocalize regularly (i.e., at least every few min) during the time period in which they are being localized. Violations of these assumptions might result in animals that are actually located inside the EZ, being localized outside of the EZ by the system, or vice versa, animals that are actually located outside the EZ, are localized inside of the EZ. These uncertainties are a limitation of the localization method used.

In addition, TMA localization methods assume that animals are not diving deeper than the horizontal distance from the array. If they do, then there is a chance that the localization will indicate that they are outside the EZ, when they are in fact, inside of it. We consider this possibility unlikely because animals would need to dive to a water depth exceeding the radius of the EZ (e.g., over 904 m depth), which few species of cetaceans are capable of doing. Even for those that are capable of doing so, a common response of deep-diving cetaceans to MFAS is to move horizontally away from the source and ascend (Tyack et al. 2011); therefore, it seems unlikely they would remain within the EZ.

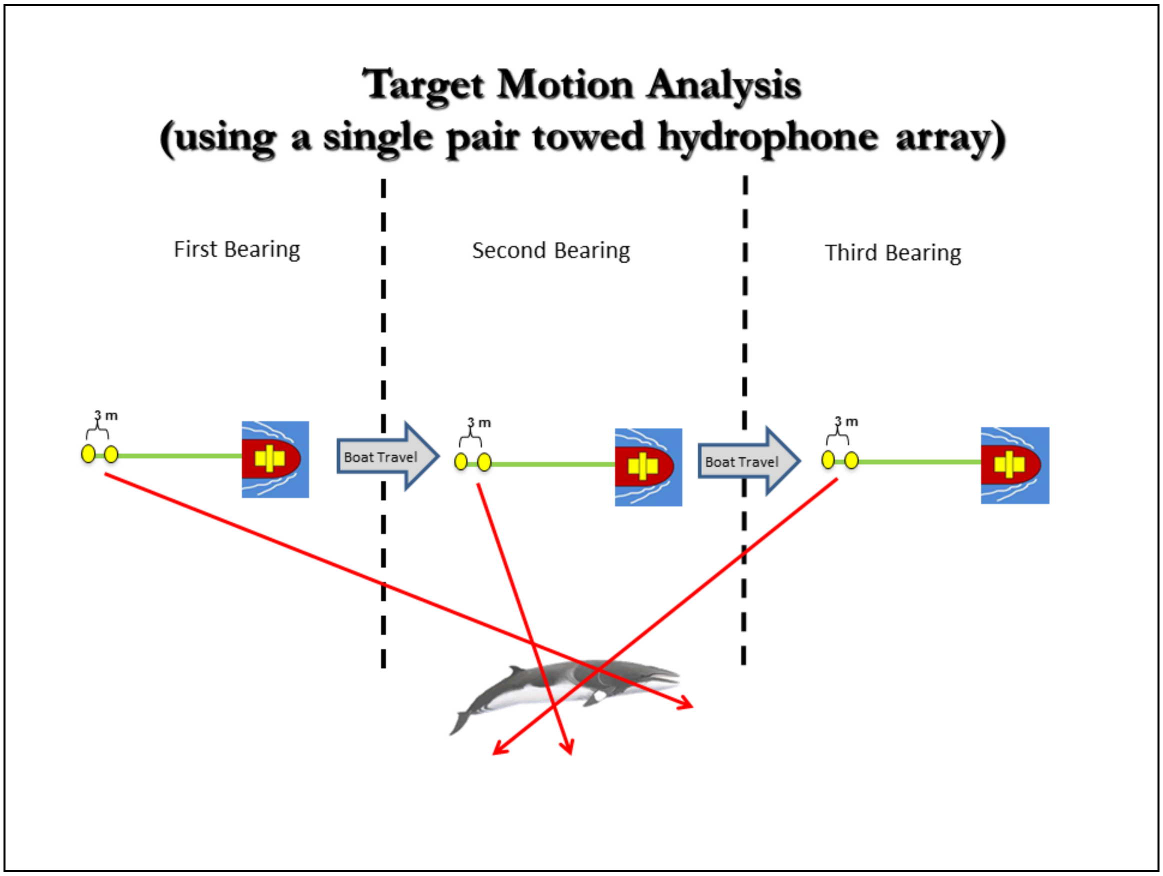

Figure 11-1. Illustration of how target motion analysis (TMA) works. Each dotted line represents a moment in time as the boat moves from left to right. Bearings converge at the location of the animal. Note that the bearings (usually) do not converge perfectly, due to errors in the bearing estimation, animal movement, or uncertainty in knowing the exact location and orientation of the towed hydrophone array.

Both 'manual' and semi-automated methods will be used to acoustically monitor, track and localize marine mammals. The 'manual' system will consist of 2 computers running various software. At least 2 computers are required because some software systems work well with cetacean species that produce clicks (e.g., PAMGuard) while others work better with tonal sounds such as whistles produced by dolphins and whale calls (e.g., Ishmael). Also, manual methods are required to detect and localize whistling and moaning species (e.g., dolphins, North Atlantic right whales, sei whales, and minke whales), using the software program Ishmael (Mellinger et al. 2007).

The semi-automated system involves running PAMGuard software (Gillespie et al. 2008) in real-time to detect and track all echolocation clicks, and to classify echolocation clicks for some echolocating species (e.g., beaked whales, sperm whales, and killer whales). Using PAMGuard, echolocation click trains can be assigned to individual animals (or animal groups). Bearings are plotted to PAMGuard's mapping display to calculate/estimate localization. All acoustic encounters will be logged to a database, and perpendicular distances from the array will be obtained and recorded for all possible acoustic encounters. Monitoring effort, trackline position, and visual observation status will be recorded using digital forms in PAMGuard. PAMGuard uses a customizable Microsoft Access™ database that allows users to enter data that are then saved for easy collection of metadata and post processing. Each time there is a change in effort status (either for the acoustic or visual teams), such as turning onto a new trackline or a change in the acoustician monitoring effort status, the information is recorded. This database will be used to record acoustic encounter details (e.g., initial date/start time, end date/time, acoustic ID, species ID). All acoustic localizations are assigned quality assessment scores based on a subjective assessment of the localization quality by the acoustic PSO.

When a vocalization is detected during visual observations, the acoustic PSO will contact the lead visual PSO immediately, to alert him/her to the presence and estimated range to the vocalizing cetaceans (if they have not already been seen), to allow a power down or shut down to be initiated, if required.

11.5 Establishment and Monitoring of Exclusion Zones

Current NMFS guidelines (65 FR 16374) define "exclusion radii", hereafter referred to as EZs, for marine mammals around industrial sound to be 180 dB re 1 μPa (rms) for cetaceans and 190 dB re 1 μPa (rms) for pinnipeds. Such guidelines are in place to minimize disturbance or behavioral effects to marine mammals. This is based on NMFS' assumption that sound energy at lower RLs will not impair their abilities to hear, but higher RLs may have such effects (NMFS 2005b). Estimated distances to the EZs proposed to be implemented during this seismic program for a full array nearest in size to the proposed WesternGeco full array and for the mitigation seismic source are presented in Table 1-1 and Table 1-2.

PSOs aboard the seismic vessels will perform a substantial role in monitoring for marine mammals and implementing mitigation measures. Aboard the seismic vessel, PSOs will monitor for marine mammals prior to initiation of the seismic source to ensure none are detected within the specified EZs for at least a 60 min period prior to any seismic sources being turned on.

11.6 Mitigation during Operations

WesternGeco will adhere to the following mitigation measures during seismic operations, when mobilizing to the survey area, when demobilizing from the survey area, and in the performance of any other operations in support of the 2D seismic program:

- Speed or course alterations for marine mammals, provided that doing so will not compromise safety of the operations.

- The seismic vessels will be staffed with visual PSOs and acoustic PSOs who will alert the crew to the presence of marine mammals so that vessel and seismic source crews can implement the appropriate mitigation measures, including power-down, shut-down, and ramp-up procedures.
- Initiation of the seismic source will occur only after the 180 dB EZ is visible for 60 min immediately prior to seismic operations (i.e., the 'all-clear period') during day or night using continuous PAM supplemented by visual monitoring.

During periods of limited visibility due to fog and/or darkness (nighttime), WesternGeco will adhere to the following:

- If this entire 180 dB EZ is not visible for a minimum of 60 min prior to initiation of seismic operations, the seismic source will not operate unless acoustic PSOs have monitored for the 60 min immediately prior to seismic operations with no marine mammal determined to be calling within the estimated EZ.
- If a single seismic source or source array has been operational before visibility decreased or before nightfall, seismic source operations may continue even though the entire EZ may not be visible.
- If limited visibility appears imminent due to inclement weather, the mitigation seismic source may be operated when the EZ has been continuously monitored and determined to be clear of visual sightings and localized calls of marine mammals for the 60 min immediately prior to initiation of the mitigation seismic source.

11.6.1 Speed or Course Alteration

If marine mammals have been detected or are seen outside the EZ but are likely to enter the EZ based on observed movements, the seismic vessel will adjust (increase or decrease) speed or change its course to avoid disturbing the marine mammals. This procedure will be conducted with safety and practicality in mind, and further course alterations or seismic source power downs will occur if necessary.

11.6.2 Power-down Procedures

Power-down procedures include reducing the seismic source array volume (by reducing the number of active sources) thereby reducing the 180 dB and 190 dB EZs to an extent that the marine mammal(s) are no longer within the applicable zone.

If marine mammals are detected entering the appropriate EZ, except when bowriding, a power down will be immediately requested by the PSO to power down to the 105 in^3 (or smaller) mitigation seismic source. Similarly, if marine mammals are detected within the appropriate EZ, a power down will be requested immediately as long as marine mammals are not within or approaching the reduced EZ of the single or mitigation seismic source. Measured reported maximum distances for a 90 in^3 (similar to 105 in^3) mitigation seismic source were reported in BOEM (2014a) as recorded by JASCO Applied Sciences as follows: 76-186 m for the 180 dB isopleth, and 1,294-3,056 m for the 160 dB isopleth. WesternGeco will use the mean of the 95 percent range values of the modeled RL for each of the 21 scenarios of these distances for the purposes of mitigation and monitoring. If marine mammals continue to approach the reduced EZ of the mitigation seismic source, this single seismic source will be shutdown (Section 11.6.3).

Power downs may also occur when the seismic vessel is transitioning between survey lines. In this case, the seismic source will be reduced to a single 105 in^3 (or smaller) mitigation seismic source or optionally will shut down completely (Section 11.6.3).

Use of the 105 in^3 mitigation source is intended to alert marine mammals of the presence of a sound source in the environment and to retain the option to initiate seismic source ramp-up procedures (Section 11.6.4) under conditions of limited visibility or darkness.

Once powered down, seismic source operations will only resume once the marine mammals have been confirmed outside the EZ. A marine mammal is considered to have cleared the zone if:

- It has been visually detected outside of the full-zone EZ;
- It has not been observed for 60 min;
- The vessel has moved outside the EZ.

11.6.3 Shut-down Procedures

Shut-down procedures consist of a complete cessation of the seismic source. These procedures will be implemented if marine mammals are observed within the appropriate EZ (Section 11.5). Once shut down, seismic source operations will only resume after the marine mammals have been confirmed to be outside the EZ and the zone has been clear for at least 60 min as described for power downs (Section 11.6.2). Exceptions will be made, and shutdown is not required for delphinids (i.e., dolphins) that are approaching or remain near any vessel or the towed equipment (BOEM 2014b). The visual and acoustic PSOs must record the details of any non-shutdowns in the presence of delphinids, including the distance of the delphinid(s) from the vessel at the first sighting of the delphinid(s), their heading, where the delphinid positions itself relative to the vessel, how long they stay near the vessel, and any identifiable behaviors (BOEM 2014a). After a shutdown, the operator may recommence seismic operations with a ramp-up of the seismic source only when the acoustic EZ has been visually inspected for at least 60 min to help ensure the absence of all marine mammals (BOEM 2014a).

Shutdowns will occur immediately if observations are made or credible reports are received that 1 or more marine mammals within the seismic survey area are injured, dead, dying, or indicate acute distress due to seismic noise. In this case an emergency shutdown will be ordered and NMFS will be contacted immediately. If it can be determined that the marine mammal(s) injury or death is likely not due to seismic activities (e.g., obvious signs of killer whale predation, ship strikes), WesternGeco will collect information as specified in Section 13 of this document, notify NMFS, and resume seismic activities. If cause of death cannot be attributed to causes other than the seismic program, the activities will not be restarted until approval has been given by NMFS.

11.6.4 Ramp-up Procedures

Ramp up (also known as soft start) procedures involve a stepwise increase in the number and volume of the seismic source to provide a gradual increase of sound levels into the environment until maximum levels are reached. This procedure is intended to alert marine mammals of seismic activity in the area, allowing them time to leave the area so as to avoid injury or hearing impairment.

Operators will visually monitor the EZ and adjacent waters for the absence and/or presence of marine mammals for 60 min before initiating ramp-up procedures. If marine mammals are not detected, ramp-up procedures may begin. Ramp up at night or when the EZ cannot be visually monitored is not permitted if the minimum SL drops below 160 dB re 1 μPa m (rms) (see measure D) (Taken from the BOEM ROD, BOEM 2014a). Chronological procedures of a ramp up process are listed below.

1. Initiate ramp-up procedures by use of the single 90 in^3 mitigation source.
2. Continue ramp up by gradually activating additional sources over a period of at least 20 min, but no longer than 40 min, until the desired operating level of the source array is obtained.
3. Immediately shut down all sources (i.e., stop seismic operations) any time marine mammals are detected entering or within the EZ. After a shutdown, ramp up and seismic operations may restart only if the EZ has been visually inspected for at least 60 min prior to ensure the absence of marine mammals within the EZ.
4. After a complete shutdown, ramp-up procedures will not begin until the EZ for the full seismic array is visible and no marine mammals are present. In this case of a "cold start," the EZ must remain completely visible during the entire 60 min period. If marine mammals are observed within the appropriate EZ, a cold start may not be initiated until the animal is observed outside the EZ or not observed for at least 60 min.

Periods of source silence for ≤ 20 min in duration will not require ramp up to recommence seismic operations if (a) visual surveys are continued diligently throughout the silent period (requiring daylight and reasonable sighting conditions), and (b) no marine mammals are observed in the EZ (BOEM 2014a). If marine mammals are detected in the EZ during the short silent period, recommencement of seismic survey operations must be preceded by ramp up only after no marine mammals have been observed in the EZ for a period of 60 min (BOEM 2014a).

Array SLs may be reduced to maintain a minimum SL of 160 dB re 1 μPa-m (rms) for the duration of certain activities (BOEM 2014a). The 60 min visual clearance of the EZ before ramp up to full power is not required if the minimum SL of 160 dB re 1 μPa-m (rms) is maintained (BOEM 2014a). Activities that are appropriate for maintaining the minimum SL are (1) all turns between seismic survey lines, when a survey using the full seismic array is being conducted immediately prior to the turn and will be resumed immediately after the turn; and (2) unscheduled, unavoidable maintenance of the seismic source array that requires the interruption of a survey to shut down the seismic array. The survey should be resumed immediately after the repairs are completed, but should not exceed 20 min. Use of the minimum SL to avoid the 60 min visual clearance of the EZ is only for events that occur during a survey using the full power array. The minimum sound SL is not to be used to allow a later ramp up after dark or in conditions when ramp up would not otherwise be allowed.

To reduce to overall contribution of project-related seismic sounds, during turns and transits between survey lines while the single 105 in^3 mitigation source is operating, WesternGeco proposes to decrease the seismic source pulse interval to 60 sec. The proportion of time that the seismic array will actually be operating (i.e., "on") is very small compared to the proportion of time that WesternGeco will be in the survey area. This is because each pulse with the full seismic array lasts only about 3 milliseconds, and is repeated at an interval of approximately 10 sec. Furthermore, each 3-millisecond pulse by the mitigation source is proposed to be spaced apart by 60 sec. The latter mitigation measure was recently approved by a NMFS review panel and thus implemented for a seismic survey with a large seismic source array during a TGS seismic survey in the Chukchi Sea in summer-fall 2013 (NMFS 2013, Cate et al. 2014).

11.6.5 Procedures for Species of Concern

If a North Atlantic right whale is encountered at any distance from the seismic vessel, seismic operations will be shut down immediately due to the rarity of this federally endangered status. It is not likely that concentrations (large amounts in one place) of humpback, fin, sperm, blue, or sei whales would be encountered, but if so, they will be avoided.

11.6.6 Use of a Small-volume Seismic Source during Turns and Transits

Throughout the seismic survey, particularly during turning movements, and short transits, WesternGeco will employ the use of small-volume source (i.e., 105 in^3 "mitigation source"). The mitigation source will be operated at approximately one shot per minute and will not be operated for longer than three hours in duration during daylight hours and good visibility. In cases when the next start-up after the turn is expected to be during lowlight or low visibility, use of the mitigation source may be initiated 30 minutes before darkness, or low visibility conditions, and may be operated until the start of the next sail line. The mitigation source must still be operated at approximately one shot per minute.

During turns or brief transits (i.e., less than three hours) between seismic tracklines, one mitigation source will continue operating. The ramp-up procedure will still be followed when increasing the source levels from one acoustic source to the full array. However, keeping one acoustic source firing will avoid the prohibition of "cold start" during darkness or other periods of poor visibility. Through the use of this approach, seismic surveys using the full array may resume without the 60 minute observation period of the full EZ required for a “cold start." PSOs will be on duty whenever the sources are firing during daylight, during the 60 minute periods prior to ramp-ups.

11.6.7 Time-area/Speed Restrictions for North Atlantic Right Whales

Ten kt (18 km/hr) speed limits are in effect annually from November 15 to April 15 within the Southeast SMA (NMFS 2014). In the Mid-Atlantic SMA, the same speed restrictions are in effect annually from November 1 through April 30 (Appendix A, Table A 1) (NMFS 2014). Within the North Atlantic right whale critical habitat off the southeast U.S. coast, the annual calving and nursing season extends from November 15 through April 15 (Appendix A, Table A 1) (NMFS 2014). A minimum of 500 m must be kept from any North Atlantic right whale that is sighted, 100 m from other whale species, and 50 m from all other marine mammals (BOEM 2014b). DMAs are designed to reduce the risk of whale-ship interactions when right whale(s) are found aggregating in an area. All project vessels will abide by these time-area /speed restrictions when they are in effect. Seismic operators will also be required to ensure that sound from surveys outside of North Atlantic right whale critical habitat, the SMAs, or DMAs does not exceed 160 dB at the boundaries of the time-closure areas (BOEM 2014b).

11.7 Communication Procedures

When visual or acoustic PSOs detect marine mammals within or approaching the applicable EZ, the seismic source will be powered down or shut down immediately. To facilitate this, PSOs will establish a direct line of communication with the seismic source operators (traditionally via VHF radio). PSOs will continue to monitor the EZ after the power or shut down. The PSOs will communicate resumption of the array source if the marine mammal(s) is observed outside and moving away from the applicable EZ within 5 min of the power down or shut down. If over 5 min have elapsed since the seismic source was reduced in volume or shut down, then the EZ must be clear of marine mammals for at least 60 min or as stipulated in the NMFS-issued IHA. Once the PSO(s) has cleared the zone, they will communicate to the seismic source operators to initiate ramp-up procedures (Section 11.6.4).

12 Plan of Cooperation

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a "plan of cooperation" or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

The Plan of Cooperation is not applicable. The proposed activity is located in the mid- and south Atlantic Ocean, where no activities will take place in or near a traditional Arctic subsistence hunting area.

13 Monitoring and Reporting Plan

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as fee.

13.1 Monitoring

WesternGeco proposes to implement mitigation and monitoring measures that will contribute to increased knowledge of marine mammal species that are likely to be exposed to project-related seismic activity noise at RLs of ≥ 160 dB re 1µPa (rms). As summarized in Section 7, such exposures are expected to be limited to potential Level B take consisting of short-term and localized changes in animal behavior and distribution and extremely infrequent Level A take that will not result in serious injury or mortality while the seismic source is operating. The proposed means of increasing knowledge on marine mammals in the survey area include:

1. Visual observations of marine mammal species seasonal and geographical occurrence, location and behavior during periods with and without seismic operations, facilitating comparisons of these parameters relative to seismic activities;
2. Real-time PAM during periods with and without seismic operations to provide data on cetacean species calling patterns seasonally, geographically, behaviorally, and relative to seismic sounds;
3. Contributing marine mammal sighting data to the OBIS SEAMAP and CetMap online public database (see Section 13.1.7);
4. Coordinating monitoring efforts with other groups conducting research on and/or mitigation/monitoring of marine mammals in overlapping or nearby regions and periods;
5. Conducting analyses and writing reports to NMFS that satisfy NMFS IHA requirements.

These approaches and associated proposed survey techniques will be used to monitor and describe marine mammal movement, vocal and visually observed activity and behavior, habitat use, distribution, and density and abundance (sample sizes permitting) within the survey area relative to seismic operation as described in ensuing sections. The latter will include comparison of these aspects during periods with and without seismic transmissions, and other project conditions (e.g., ramp up, mitigation versus full seismic array operations) sample sizes permitting.

WesternGeco understands that the monitoring plan described in this section will be subject to review by NMFS and others and that modification may be required. WesternGeco is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical. The latter would consist of communicating prior to and during the proposed seismic survey with entities involved in temporal-spatially overlapping research and monitoring. Goals would include coordinating timing and locations of WesternGeco's proposed monitoring programs to complement one another and to address research and conservation needs as possible/applicable.

13.1.2 Vessel-based Visual Monitoring

Vessel-based PSOs will observe from the seismic vessels to monitor the presence and behavior of marine mammals during all daylight seismic operations. The primary purpose of the visual PSOs is to visually monitor the EZs and implement mitigation measures (e.g., ramp ups, power downs, and shut downs of the seismic source) as described in Section 11 for marine mammals. All observer résumés will be submitted to BOEM and NMFS for approval prior to survey operations, as identified in the BOEM PEIS (BOEM 2014a). Vessel-based visual monitoring by PSOs will provide:

- The foundation for real-time mitigation as required by the permitting agencies;
- Information necessary to estimate the number of "take" exposures of marine mammals to seismic operations noise that must and will be reported to NMFS;
- Information necessary to evaluate the impact of activities authorized by the IHA on marine mammals;
- Marine mammal distribution, movement, and behavioral data within view of the seismic vessels and PAM recording range when seismic source operations are on and off.

13.1.3 Protected Species Observer Protocol

To adequately monitor proposed EZs during all daylight and nighttime seismic operations and mitigation periods, 3 to 5 visual PSOs and 2 acoustic PSOs are proposed to be aboard the seismic vessels, depending on the amount of daylight hours each day, and based on seasonal variation in the number of daylight hours. Aboard the seismic vessels, PSO rotations will be scheduled so that at least 2 PSOs will be on watch during all daylight periods (from civil twilight-dawn to civil twilight-dusk) with seismic operations as well as during the 60 min pre-ramp up "all clear" period and the ensuing ramp up; 2 PSOs will also be on watch aboard the seismic vessel during other non-seismic daylight periods to the maximum extent practicable, with at least 1 PSO on watch during meal times and restroom breaks. PSOs will also conduct monitoring while the seismic source vessel deploys and recovers the seismic source from the water (BOEM 2014a). Daily PSO rotations will be scheduled such that each PSO will be on continuous watch for no more than 4 hr at a time, and for no more than 12 hr total per 24 hr period to avoid and minimize PSO fatigue. A "lead PSO" will be designated for each vessel to oversee PSO data quality assurance / quality control (QA/QC) and compile and send any field reporting required per the NMFS IHA and BOEM.

They will receive a detailed manual summarizing PSO protocol and mitigation procedures as stipulated in the permits and issued IHA, and as described in the BOEM PEIS (2014a) and associated NMFS Biological Opinion (BOEM 2014a). The latter protocol will be provided to NMFS as requested. PSOs will follow the reporting requirements identified in the permits and issued IHA. Once onboard the vessels and prior to the survey's start, the lead PSO on the seismic vessel will communicate the role of the PSO teams to the vessel crew(s). This will include establishing an effective method of communication for relaying mitigation requests to the seismic source operators (see below).

Marine mammal visual observations will be conducted from the bridge or other suitable platform on the seismic vessels. On the seismic vessel, the 2 on-watch PSOs will scan waters within view for marine mammals: 1 PSO will alternate between the naked eye and handheld reticle binoculars (e.g., 7x50 Fujinon™), with the other using the big-eye binoculars (Fujinon 25×150 or equivalent, if space and safety allow). Whichever PSO sights a marine mammal(s), the other will record sighting data on a GPS-connected laptop computer.

PSOs will record data on marine mammal sightings, vessel and seismic activities, and environmental conditions (every 30 min on the hr and half hr, and when a sighting occurs). Specific data parameters that will be collected include species, group size/composition, location relative to the seismic array position, distance from the survey vessel, and behavior.

13.1.4 Data Recording

The operator of the seismic vessel will maintain a log of seismic surveys, noting the date and time of all changes in seismic activity (ramp up, power down, shut down, changes in the active seismic source, etc.) and any corresponding changes in monitoring radii. Information collected during marine mammal observations will include the following:

- Vessel speed, position, and activity including seismic status;
- Date, time, and location of each marine mammal sighting relative to the seismic source(s) and/or array, and PSO position;
- Number of marine mammals observed, and group size, sex, and age categories as possible;
- Observer's name and method of determining distance to the sighting (e.g., naked eye, reticle binoculars, big eye binoculars);
- Beaufort sea state, visibility distance, and weather conditions at the time of observation;
- Estimated distance, behavior state (e.g., traveling, resting) and relative heading of marine mammals at first-observed, last-observed, and closet point of observed approach (CPA), as applicable;
- Animal behavioral events (e.g., breach, tail slap) and any unusual behaviors;
- Description of the encounter;
- Duration of encounter;
- Mitigation action(s) taken.

13.1.5 Passive Acoustic Monitoring

As described in Section 11.4, WesternGeco proposes to use a towed passive acoustic array to meet the PAM requirement identified in the BOEM ROD (BOEM 2014b). Passive acoustics methods can be very effective for long-term monitoring (Mellinger et al. 2007). Per the Draft NMFS-BOEM Mitigation and Monitoring workshop (BOEM 2012),

"Monitoring should be designed to accomplish or contribute to one or more of the following top-level goals:

1. An increase in our understanding of:
    - The likely occurrence of marine mammal species or stocks (e.g., presence, abundance, distribution, and/or density of species);
    - The nature, scope, or context of the likely exposure of marine mammal species or stocks to any of the potential stressor(s), by understanding:
        - The action itself and the surrounding environment;
        - The affected species (life history, habitat use, hearing sensitivity);
        - The likely co-occurrence of marine mammal species or stocks with the action (in whole or part);
        - The likely biological or behavioral context of exposure to the stressor (e.g., age class or known calving or feeding areas);
        - How marine mammals respond (behaviorally or physiologically) to the specific stressors associated with the action (in specific contexts, where possible, e.g., at what distance or RL);
    - How anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either:
        - The long-term fitness and survival of an individual or
        - The population, species, or stock (e.g., through effects on annual rates of recruitment or survival); and,
2. An increase in our understanding of the effectiveness of mitigation and monitoring measures".

Monitoring is a stipulation identified by NMFS during the IHA process and is thus included in standard IHA applications submitted to NMFS (e.g., Cate et al. 2014, LGL 2014a).

Towed hydrophone arrays require a mobile a platform (e.g., a survey vessel or aircraft) to deploy, monitor, and operate them.

Line-transect survey and analytical methods are relatively well developed for estimating abundance of marine mammals using visual sighting data (Holt 1987) and if sufficient data exist, may be applied for visual data obtained during the proposed visual monitoring of marine mammals. Line-transect methods are a subset of well-developed statistical methods for animal density estimation methods known as Distance Sampling (Buckland et al. 2001). Line-transect methods require accurate measurements of the perpendicular distances of individual or compact groups of animals from the survey-track. These distances are then used to estimate a 'detection function', an important component of the density estimation formula that models the decrease in detectability of animals with increasing distance from the trackline.

The same analytical approach that is used for visual-based line-transect surveys can be applied to acoustic data. Data collected from TMA localization methods can be used to estimate the perpendicular distance of animals, or compact groups of animals from the trackline. These methods have been used by researchers to localize marine mammals using a towed hydrophone array (Leaper et al. 2000; Lewis et al, 2007). These data can then be used to calculate a detection function (Lewis et al. 2007). In cases in which individuals cannot be reliably localized, visual data about group sizes are needed to estimate densities (Barlow and Taylor 2005).

13.1.6 Aerial Monitoring

WesternGeco does not intend to conduct aerial surveys as part of the monitoring and mitigation plan for the MSA OCS seismic survey as they would be impractical and unsafe due to the location and distance to offshore waters of the survey area (Figure 2-2). PAM and vessel-based visual methods are considered more effective monitoring methods overall, since they can be conducted during all daylight and/or 24-hr per day (the latter using PAM) from vessel platforms that are part of the survey operations.

13.1.7 OBIS-SEAMAP

OBIS-SEAMAP is an interactive online, spatially referenced database of marine mammal, sea turtle, and seabird observations and locations from around the world that are publicly accessible (http://seamap.env.duke.edu/). The database system is used to aggregate and assimilate these observational data to assist in better understanding, accessing and applying of data useful to the public, managers, scientists, etc. OBIS-SEAMAP is continuously being updated by contributions of marine mammal data collectors and researchers around the globe. The goal of this archive is to quantify the patterns of worldwide marine species distribution and biodiversity. In order to contribute to this on-going effort, all marine mammal and sea turtle occurrence data collected during the survey, both through visual observations and PAM detections will be provided to OBIS-SEAMAP.

13.2 Reporting

During the field season, brief summary reports will be provided to NMFS, as required per the IHA.

Results of the vessel-based PSO program, including estimates of exposures to seismic sounds, will be described in a report to be submitted within 90 days of the end of the program. This report will adhere to the requirements established by the NMFS IHA and will include the following:

- A summary of the monitoring effort;
- Analysis of factors affecting the visibility and detectability of marine mammals during monitoring;
- Analysis of distribution and abundance of marine mammal sightings, and description of marine mammal behavior and movement in relation to date, location, conditions, and operations including periods of seismic on and off;
- Estimates of numbers of exposures of marine mammals by species and NMFS exposure criteria based upon density estimates derived from visual (and if possible) passive acoustic monitoring and survey efforts (sample sizes permitting);
- Reporting of acoustic monitoring results to include: sound RLs of seismic source(s) and seismic vessels, acoustic detections of marine mammals, and continuous sound levels at the stationary recording locations;
- Estimates of directly observed exposures to seismic operations relative to NMFS exposure criteria.

14 Coordinated Research to Reduce and Evaluate Incidental Take

Suggested means of learning, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

To reduce and evaluate incidental take, WesternGeco will encourage and coordinate collaborative research opportunities within state and federal divisions. Active communication will ensure proper regulatory compliance and thus may reduce incidental take. Contacts such as NMFS can assist with marine mammals or avian interactions and abnormal behavior. WesternGeco is committed to coordinating with other monitoring programs to ensure that all measures are taken to minimize any impacts from its 2D seismic program.

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Appendix A Right Whale Critical Habitat and Seasonal Management Areas

Table A 1. Designated Seasonal Management Areas for the North Atlantic Right Whale.

Designated Area	Individual Areas	Concerns	Period Of Activity
Northeast U.S. Seasonal Management Areas	Cape Cod Bay	Feeding Area	January 1–May 15
	Off Race Point	Feeding Area	March 1–April 30
	Great South Channel	Feeding Area	April 1–July 31
Mid-Atlantic U.S. Seasonal Management Areas	Block Island Sound		
	Ports of New York/New Jersey		
	Entrance to Delaware Bay	Migratory Route and	November 1–April 30
	Entrance to Chesapeake Bay	Calving Grounds	
	Ports of Morehead City and Beaufort, NC		
	Wilmington, NC to Brunswick, GA		
Southeast U.S. Seasonal Management Area	Central GA to northeast FL	Calving and Nursery Grounds	November 15–April 15
Grand Manan Basin Critical Habitat Area	New Brunswick and Nova Scotia, Canada	Feeding Area	June-December
Roseway Basin Critical Habitat Area	South of Nova Scotia, Canada	Feeding Area	

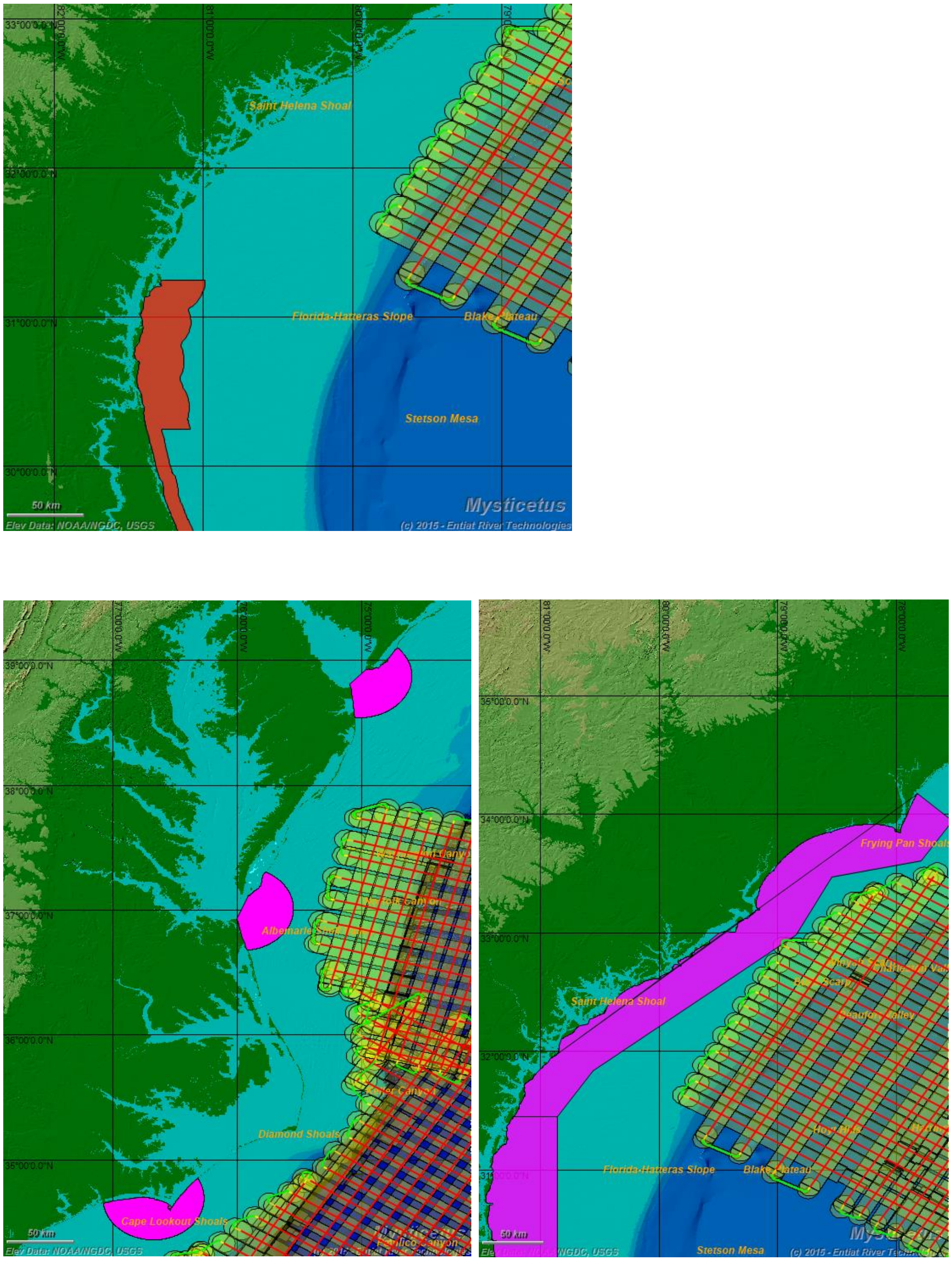

Figure A 1. Location of Designated Critical Habitat (DCH) (red polygon along shore, top map) and Designated Seasonal Management Areas (DSMA) (pink polygons nearshore, bottom maps) for the North Atlantic Right Whale relative to the estimated area ensonified to sound levels ≥ 160 (rms) during WesternGeco's Proposed 2D Seismic Survey in BOEM's mid-Atlantic and South Atlantic Planning Areas (see small overlap in bottom right map). Notes: (1) WesternGeco would not conduct seismic operations during seasonal exclusion periods in the DSMA in the small area of overlap indicated on the bottom right map; and (2) there is no overlap with DCH and less than 1 km^2 overlap with DSMA.

Appendix B Seismic Array and Vessel Characteristics

Table B 1. Acquisition parameters associated with WesternGeco's proposed two-dimensional (2D) seismic operations with a 5,085 in^3 seismic array and characteristics of the BOEM-modeled 5,400 in^3 seismic array.

Acquisition Parameters		
	WesternGeco Actual Proposed Seismic Array	**BOEM-modeled (BOEM 2014a) Full Array Applied in this IHA**
Seismic Source Type	Bolt v5085	
Total Volume	5,085 in^3	5,400 in^3
Sub Array Volume	1,695 in^3	105-660 in^3
Number of Operating Acoustic Sources in Full Array	24	18
Number of Sub Arrays	3	3
Source Depth	10 m	6.5 m
Total Energy Output Peak to Peak in dB	262 dB re 1 µPa @ 1 m	247 db re 1 µPa @ 1 m
Total Energy Output rms in dB	235 dB re a µPa @ 1 m	

This 5,400 in^3 seismic array modeled in the BOEM Atlantic PEIS (BOEM 2014a) was the conservatively closest in size to WesternGeco's actual proposed 5,085 in^3 seismic array, based on a review of available literature on modeled and empirically measured sound source verification studies. See Section **Error! Reference source not found.**.

Figure B 1. Chase Vessels

Figure B 2. Supply Vessel.

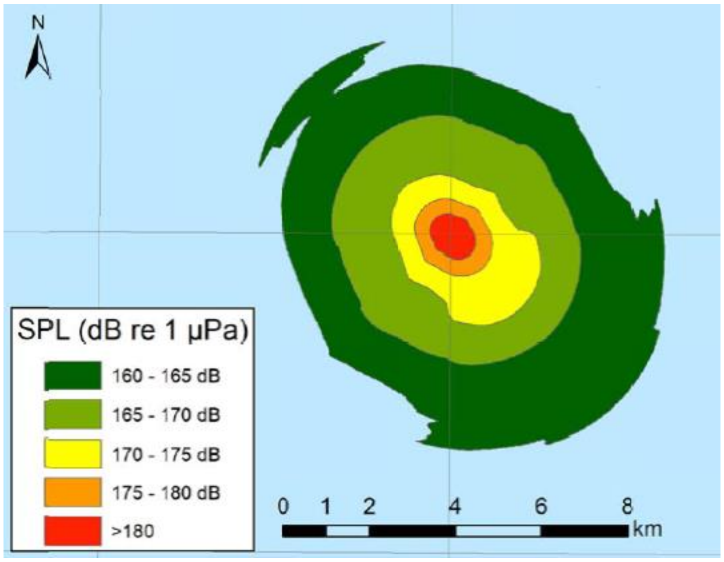

Figure B 3. Plot from JASCO modeling of Sound Pressure Level (SPL) in dB re 1μPa of 5,085 in^3 WesternGeco seismic sound source.

The model indicated ≥ 160 dB sound level to approximately 5,500 m from the source. This model is theoretical and so is not based on empirically derived sound levels in the ocean and was meant to simulate sound propagation in the Gulf of Mexico. However, this modeling suggests that the 160 dB (rms) radius around the seismic sound source is not more powerful than that modeled in the BOEM PEIS (BOEM 2014a). Mean distance to the 160 dB (rms) received level in the BOEM PEIS model array was 6,838 m (based on mean of $R_{95\%}$ of RL values from BOEM (2012a) Table D-22).

Appendix C Marine Mammal Seismic Source Exposure Estimation Methods

The method used to estimate the potential number of individual marine mammals exposed to seismic sounds associated with the proposed WesternGeco 2D seismic program is described in detail below with respect to modeling using CetMap data. See Section 6.3 for information about how estimates of potential exposures were made for species that were not evaluated using the CetMap dataset.

To estimate Level B exposures using CetMap, NMFS' recommended 160 dB (rms) isopleth was used (Table C 1). The approach involved multiplying animal density by the area estimated to be ensonified by sounds from an operating seismic array (or alternatively, a single mitigation sound source). The size of the estimated ensonified area is based on the modeled radial distance from the selected seismic source to the sound exposure criteria isopleths. This approach for estimating exposures applies the notion of instantaneous sound exposure levels and thus a static animal distribution while a seismic source instantaneously "moves" along projected seismic lines. For this project, isopleth distances were based on those modeled by JASCO for the 5,400 in^3 array and 90 in^3 mitigation sound source as reported in the BOEM PEIS (BOEM 2014) (see Sections 1.2 and 2.0). Software modelling applied for this approach was more complex than a simple spreadsheet multiplication or GIS analysis typically undertaken for Level B exposure estimates. However, it is considerably less complex than the sound propagation and/or probabilistic animat modelling that was used to estimate sound exposures in the BOEM PEIS (BOEM 2014a).

Table C 1. Seasonal and average Level B (rms) estimated marine mammal exposures estimated using CetMap data for WesternGeco's proposed 2D seismic survey on the mid- and South Atlantic Outer Continental Shelf.

Species	January	February	March	April	May	June	July	August	September	October	November	December	Average
Humpback whale	60	60	60	117	113	36	5	2	7	26	52	52	**49**
North Atlantic right whale					22	9	3	0	0	1			**6**
Atlantic spotted dolphin													**19,063**
Bottlenose dolphin	27,250	29,874	27,786	19,317	19,590	15,849	19,960	25,827	24,121	20,358	26,269	29,984	**23,849**
Pilot whales													**4,766**
Risso's dolphin	755	770	1,171	1,943	1,616	2,583	2,722	2,382	1,671	1,803	1,313	797	**1,627**
Short-beaked common dolphin	23,736	26,832	22,576	21,930	21,705	15,319	19,614	20,876	15,135	16,390	20,731	26,390	**20,936**
Sperm whale	1,570	1,474	1,428	1,625	1,893	2,318	2,571	2,603	2,399	2,370	2,022	1,734	**2,001**
Striped dolphin													**9,191**
Beaked whales													**5,095**

Level A Southall criteria exposures were estimated for general reference, though no Level A exposures are expected or requested (Table C 2). This was done by determining the ratio (i.e., proportion or percentage) of the total linear km of proposed WesternGeco seismic lines (26,641 km) to the total number of seismic survey lines (217,850 km) modeled in the BOEM PEIS (BOEM 2014a) for the 5,400 in^3 seismic array in the year 2015. This showed that the WesternGeco total seismic line length was 12% of the 2015 total linear line length modeled by BOEM.

Table C 2. Potential Level A exposures assuming no mitigation were being used based on Southall et al (2007) criteria applied in BOEM (2012a; Table 4-9). WesternGeco is proposing 26,641 km of trackline at full power (5,085 in^3 source). Because BOEM (2012a) does not address mitigation power or turns/transits in its Southall-based Level A exposure estimates, we assume 26,641 km of WesternGeco trackline for comparison with BOEM (2012a) Southall-based estimates. Because total BOEM (2012a) includes 217,850 km of trackline, the percent of this trackline that would include WesternGeco's seismic trackline is 12%.

Species	Total BOEM (2012a) Estimated Southall-based Level A Exposures for 217,850 km of Trackline	12% of BOEM (2012a) Estimated Southall-based Level A Exposures for 217,850 km of Trackline[^&]
Common minke whale	0.161	0.019
Sei whale	0.402	0.048
Bryde’s whale	1.237	0.148
Blue whale	1.622	0.195
Fin whale	0.000	0.000
North Atlantic right whale	0.071	0.009
Humpback whale	5.931	0.712
Short-beaked common dolphin	225.454	27.054
Pygmy killer whale	0.312	0.037
Short-finned pilot whale	22.498	2.700
Long-finned pilot whale	117.528	14.103
Risso’s dolphin	731.439	87.773
Northern bottlenose whale	0.007	0.001
Pygmy sperm whale	0.000	0.000
Dwarf sperm whale	5.564	0.668
Atlantic white-sided dolphin	2.659	0.319
Fraser's dolphin	0.402	0.048
Sowerby's beaked whale	0.000	0.000
Blainville's beaked whale	2.816	0.338

Species	Total BOEM (2012a) Estimated Southall-based Level A Exposures for 217,850 km of Trackline	12% of BOEM (2012a) Estimated Southall-based Level A Exposures for 217,850 km of Trackline^&
Gervais' beaked whale	2.816	0.338
True's beaked whale	2.816	0.338
Killer whale	0.100	0.012
Melon-headed whale	0.312	0.037
Harbor porpoise	3.995	0.479
Sperm whale	0.184	0.022
False killer whale	0.300	0.036
Pantropical spotted dolphin	263.432	31.612
Clymene dolphin	125.855	15.103
Striped dolphin	1020.455	122.455
Atlantic spotted dolphin	1496.301	179.556
Spinner dolphin	1.184	0.142
Rough-toothed dolphin	0.000	0.000
Bottlenose dolphin	28.936	3.472
Cuvier's beaked whale	19.709	2.365

Species listed as endangered under the ESA are italicized.

The general seismic lines proposed by WesternGeco were analyzed in the BOEM PEIS and were similar in extent. Therefore, the estimated Southall Level A exposures modeled by BOEM for 2015 were multiplied by the 12% aforementioned ratio to provide a Southall Level A exposure estimate for the proposed WesternGeco seismic survey (Table C-2). (Note, the year of the estimate is not relevant, only the total linear line length modeled affects the percent.)

Notably, this approach does not account for mitigation measures that include shut down when marine mammals are approaching or inside of the 180 dB (rms) exclusion zone.

C.1. Software

The Mysticetus™ System used to estimate the number of marine mammals exposed to proposed seismic operations based on CetMap data is designed to be a cornerstone of all operations related to Marine Mammal Mitigation and Monitoring programs using Protected Species Observers (PSOs). Mysticetus is used to plan survey tracks, record in-field data, and for mapping, real-time mitigation decision support, and quantitative summary reporting. As such, it supplies a solid mapping and geo-spatial framework for hosting this exposure estimation sub-component. Source code specific to this method has been extracted from the app, and is included later in this appendix.

C.2. Density Polygons

Density values used for previous estimates have traditionally been very coarse, sometimes broken down by region. The estimation technique applied for this project used CetMap densities provided in 10 km X 10 km grids (Figure C-1). All of the available density cells were analyzed, per species, per month (if available), with the mean of all 12 months used when available (since the project is proposed to occur throughout a one-year period). These hundreds of thousands of cells (per species, month, geo-location) were translated by Mysticetus to geographic polygons and stored in standard Quadtrees (see http://en.wikipedia.org/wiki/Quadtree) indexed by geographic centroid for rapid access. Mysticetus handles differing datums by translating everything that is not in WGS84 datum (including any data) into WGS84 datum and, for area calculations, re-projecting these data into the Albers Equal Area Conic – USA Contiguous Projection. Thus, everything is in sync.

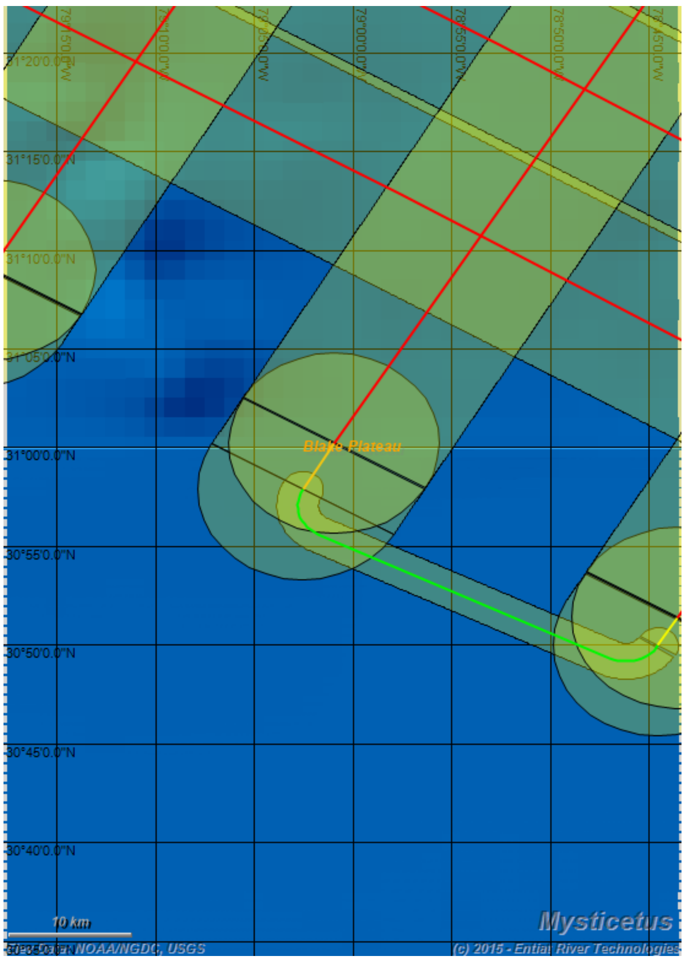

Figure C 1. Example of 160 dB (rms) ensonified regions around proposed WesternGeco 2D seismic lines as modeled for a 5,400 in^3 seismic array. Narrower zones where the mitigation sound source used are also visible.

(Note – This example is a surrogate for the actual 5,085 in^3 full seismic array proposed for the WesternGeco 2D seismic survey).

C.3. Ensonification Radius

For this project, the radius of ensonification to NMFS' recommended 160 dB (rms) received sound level isopleth consisted of the calculated mean of the 21 modelled $R_{95\%}$ values for a 5,400 in^3 and 90 in^3 seismic sources as reported in the BOEM PEIS (BOEM 2014a, Table D-22). The resulting mean radii are shown in Table C 3. For depths from 880 m - 2,560 m, there are no specific values modeled in the BOEM PEIS (BOEM 2014a), so the mean $R_{95\%}$ for all 21 scenarios (ranging from 51 m to 5,390 m) for the full 5,400 in^3 and 90 in^3 arrays were used respectively. A breakdown of the radii in BOEM (2014a) Table D-22 and the averages is shown in Table C 4.

Table C 3. Mean radii based on the $R_{95\%}$ values for the 160 dB (rms) isopleths in the BOEM PEIS used in Level B exposure estimates for the WesternGeco seismic survey.

	160 Isopleth (dB re 1 µPa [rms])
Mean modeled distance for the full 5,400 in^3 array for depths ≤ 880 m	8,473 m
Mean modeled distance for the full 5,400 in^3 array for depths > 880 m and < 2,560 m	6,838 m
Mean modeled distance for the full 5,400 in^3 array for depths ≥ 2,560 m	5,040 m
Mean modeled distance for the mitigation 90 in^3 array for depths ≤ 880 m	1,681 m
Mean modeled distance for the mitigation 90 in^3 array for depths > 880 m and < 2,560 m	1,486 m
Mean modeled distance for the mitigation 90 in^3 array for depths ≥ 2,560 m	1,271 m

Table C 4. $R_{95\%}$ values for the 160 dB (rms) and 180 dB (rms) isopleths for a 5,400 in^3 seismic source and a 90 in^3 seismic mitigation source in the BOEM PEIS (BOEM 2014a). Note the gap in depths from 880 m to 2,560 m from the BOEM PEIS (BOEM 2014a).

BOEM Modeled Scenario	5,400 in^3 180 dB (rms) (m)	5,400 in^3 160 dB (rms) (m)	90 in^3 180 dB (rms) (m)	90 in^3 160 dB (rms) (m)	BOEM Modeled Site	Season	Depth (m)
17	812	4,959	145	1,255	12	fall	4,890
1	810	4,969	144	1,256	1	winter	5,390
11	811	4,973	143	1,255	1	summer	5,390
6	811	4,989	144	1,256	1	spring	5,390
12	827	5,013	141	1,280	6	summer	3,200
7	829	5,026	142	1,281	6	spring	3,200

BOEM Modeled Scenario	5,400 in³ 180 dB (rms) (m)	5,400 in³ 160 dB (rms) (m)	90 in³ 180 dB (rms) (m)	90 in³ 160 dB (rms) (m)	BOEM Modeled Site	Season	Depth (m)
18	819	5,069	145	1,289	13	fall	3,580
16	846	5,098	145	1,285	11	fall	3,010
15	816	5,121	143	1,258	10	fall	4,300
2	827	5,184	143	1,291	2	winter	2,560
Mean Radii (m)	**821**	**5,040**	**144**	**1,271**			
8	1,091	8,056	145	2,039	3	spring	880
19	1,094	8,083	145	2,040	3	fall	880
13	1,082	8,095	143	2,036	3	summer	880
3	1,093	8,104	145	2,038	3	winter	880
21	1,677	8,384	177	2,493	15	fall	51
20	992	8,531	86	1,681	14	fall	100
9	737	8,593	74	1,331	7	spring	251
10	752	8,615	75	1,108	8	spring	249
4	748	8,725	75	1,342	4	winter	249
5	742	8,896	74	1,286	5	winter	288
14	761	9,122	74	1,100	9	summer	275
Mean Radii (m)	**979**	**8,473**	**110**	**1,681**			
Overall Mean Radii (m)	***904***	***6,838***	***126***	***1,486***			

C.4. Ensonification Polygons

To estimate the number of potential Level B marine mammal exposures, the proposed WesternGeco survey lines were surrounded with 160 dB (rms) ensonification radii (Figure C-1). Turns and transits were modeled by WesternGeco to represent the most likely locations and distances for these maneuvers. At the end of each line a 5 km run-out was included, and at the start of each line a 3 km ramp-up/run-in was included for which the array was assumed to be at full power. Between run-out of one line and run-in of the next, when < 3 hours would elapse during transit, it was assumed that the 90 in³ mitigation sound source was firing, reducing the ensonification radii to 1,271 m or 1,681 m depending on water depth (Table C-1) for purposes of exposure estimation. In cases where the turn/transit was expected to equal or exceed 3 hours to complete, the mitigation sound source would not be used (i.e., it is proposed that WesternGeco would turn off all sound sources if > 3 hours would be needed to complete a turn or transit—See Section 11.6.6 for further details). In the latter cases, zero exposures were estimated between the run-out and ramp-up/run-in.

C.5. Algorithm

A grid comprised of the individual cells was overlaid on top of the entire survey line region (e.g., see Figure C-1). Each ensonification polygon was then evaluated by Mysticetus for intersection with density grid cells. If found, the intersection of the geo-polygon of the grid cell polygon with the ensonification polygon was then determined. For each intersection (grid cell with ensonification polygon), standard quadtree pruning (a.k.a., "hit detection") was performed to obtain all appropriate density polygons that apply to this ensonified region.

If no density polygons were found to intersect this ensonification polygon region (as resulted for the area beyond the EEZ), a single density polygon covering the grid cell was synthesized. The animal density values within this single density polygon were then copied from the actual density cell geographically closest to the current location. Note that this was a potential limitation in this algorithm: for the Atlantic, the outside "band" of known density became the default value for a large swath of the open offshore Atlantic beyond the EEZ where no surveys have been conducted to provide empirical marine mammal sighting and systematic survey effort data. To account for this limitation of the model, certain other assumptions (detailed for each species) were applied. This includes not extrapolating beyond the EEZ for some species. See the per-species discussion in Section 6 for more details.

For each of these intersecting polygons (between small-scale density polygon and ensonified polygon) – the area of these intersections was determined. Determination of the geographic polygon area was highly dependent on the map projection that was used. In this case, we used the USA Contiguous Albers Equal Area Conic – USGS Version; thus, area determination calculations matched USGS values. If this algorithm is applied to areas not "near" the contiguous U.S., then another projection should be chosen. For example, applying this algorithm in the Arctic would be better served by, for example, a North Pole Stereographic projection.

At this point, the ensonification polygon intersected with a number (one or more) of density polygons. The area of each of these pruned and intersected polygons was then calculated by Mysticetus, and was multiplied by the density number for the respective density polygon. Mysticetus calculated the appropriate intersection of areas between ensonification regions and density cells and multiplied that area (in km^2) by the per-km^2 density as specified by the cell. This count was subsequently added to running totals, per species and month, as applicable, for current NMFS' recommended Level B historical exposure isopleths (Table C 1).

The end result of the abovementioned algorithm presents an abstract numerical model of the potential number of animals exposed. Further human analysis was then applied in cases where the data were sparse or the data model was judged to be too coarse.

C.6. Caveats

It should be recognized that modeled estimated marine mammal exposure numbers are only as accurate as the underlying data they represent (e.g., if based on a small sample size, then they should be considered generally less realistic or representative of the actual population than larger [e.g., >60 sightings] sample sizes (e.g., Chapman et al. 2001). Regardless of the complexity of the model applied (e.g., from the most complex modeling of animal movements and distribution with simulated animat movements to the relatively simplified standard IHA approach to estimating exposures), if the data entered into the model and/or equations are limited by small sample size and/or effort/coverage, they cannot be expected to be accurately extrapolated to a larger region or population, etc. In the latter cases, their relevance is prone to chaos theory. Resultant numbers are sometimes based on incredibly small sample sizes and a lack of complete genuine knowledge about where animals actually occur and behave at any real point in time. Large extrapolations from small data sets inevitably lead to quite variable and often unpredictable results (i.e., The Butterfly Effect).

Recognizing the caveats of relatively low sightings and effort available for the MSA OCS relative to the size of this region, when applied appropriately, the use of these limited "best available" data sets can be applied conservatively in some specific and thoroughly examined cases. For example, for endangered species breeding or migrating in certain areas (e.g., North Atlantic Right Whale Critical Habitat and Seasonal Management Areas), the associated well-documented high-use areas can be used to identify Operational Exclusion Zones that have a high probability of protecting habitat biologically important to this species. However, in other cases, there is potential for poor extrapolated densities based on the underlying inherent variability associated with a small sample size. In summary, estimated exposures to seismic sounds or other anthropogenic stimuli by marine mammals are oftentimes limited by small sample sizes used to estimate densities. Although these are the currently best available data, the resulting exposure estimates need to be considered relative to the size of the datasets upon which they are based.

Another caveat is the Modifiable Area Unit Problem (MAUP). Basically this is a statistical bias associated with the size and shape of areas associated with aggregating data. We did not choose the 10 X 10 grid size used in the CetMap dataset. Duke University has provided us with the following explanation regarding the choice of grid size and the MAUP (Jason Roberts, pers. comm. June 2015):

"The classic MAUP does not apply to our project, in the sense that we are not simply aggregating points into polygons that summarize them. Instead, we [Duke University] are splitting tracklines into segments, associating sightings (points) with segments, fitting a statistical model to the centroids of the segments, then predicting that model at the centroids of grid cells. There are various decisions that must be considered here, but for now I will constrain myself to the question of the grid cell size, to save time.

The grid cell size is 10 km x 10 km. We selected this size on the basis of several reasons:

- This resolution was specifically requested by the U.S. Navy, the primary funder of this project.
- It was a compromise between disparate resolutions of the gridded environmental datasets that served as predictor variables. The resolutions of these ranged from

30 arc-seconds, for bathymetry-derived variables (e.g., slope), to 0.25 degrees, for sea-surface-height derived variables (e.g., eddy kinetic energy).

- It resulted in statistical models that were fitted to a number of segments, and predicted for a number of grid cells, that were not so large as to be intractable with the computing resources we had readily available, while providing, in our judgement, reasonable detail at regional scale (e.g., large and moderate-scale bathymetric features, and ephemeral features such as Gulf Stream eddies were clearly preserved, rather than being smoothed out).
- Previous analyses in the Pacific (Redfern et al. 2008; Becker et al. 2010) showed either an insensitivity to spatial scale or that coarser scales worked better than finer scales, for the species and ecosystems studied. Admittedly this was for the Pacific, but it provided some evidence that it was not necessary for us to undertake an analysis at extremely high resolution (e.g., 1 or 2 km cell size).
- We conducted the analysis in an Albers equal area projection centered roughly on coastal North Carolina, which distributed the spatial error roughly evenly throughout the study area."

The references to which Jason Roberts refers in the above explanation are as follows:

Becker E.A., K.A. Forney, M.C. Ferguson, D.G. Foley, R.C. Smith, J. Barlow, J.V. Redfern. 2010. Comparing California Current cetacean−habitat models developed using in situ and remotely sensed sea surface temperature data. Marine Ecology Progress Series. 413: 163−183

Redfern J.V., J. Barlow, L.T. Ballance, T. Gerrodette, E.A. Becker. 2008. Absence of scale dependence in dolphin−habitat models for the eastern tropical Pacific Ocean. Marine Ecology Progress Series 363: 1−14

Table C 5. Breakdown of how mean group sizes were calculated for Table 6-5 for species that are extremely rare in the proposed seismic survey area.

Note that many of the groups below were not observed within the proposed seismic survey area but represent the best available information on group size in the Western Atlantic (see footnotes).

Source	Year of Survey(s)	Season	Sei Whale Groups[*]	Sei Whale Individuals[*]	Blue Whale Groups[*]	Blue Whale Individuals[*]	Pygmy Killer Whale Groups[*]	Pygmy Killer Whale Individuals[*]	Northern Bottlenose Whale Groups[*]	Northern Bottlenose Whale Individuals[*]	Fraser's Dolphin Groups[^]	Fraser's Dolphin Individuals[^]
AMAPPS 2010	2010	Summer			1	1						
AMAPPS 2011	2011	Winter	18	9								
AMAPPS 2011	2011	Summer	1	1								
AMAPPS 2012	2012	Fall	3	9								
AMAPPS 2012	2012	Spring	5	6								
AMAPPS 2013	2013	Winter			3	3						
AMAPPS 2013	2013	Summer	1	1								
AMAPPS 2014	2014	Spring	10	10	1	1						
CETAP 1982	1978-1981	Year-round	67	204	2	2	1	2	2	3		
NMFS 1993[&]	1993	Summer							1	1		
NMFS 1996[&]	1996	Summer										

Source	Year of Survey(s)	Season	Sei Whale Groups*	Sei Whale Individuals*	Blue Whale Groups*	Blue Whale Individuals*	Pygmy Killer Whale Groups*	Pygmy Killer Whale Individuals*	Northern Bottlenose Whale Groups*	Northern Bottlenose Whale Individuals*	Fraser's Dolphin Groups^	Fraser's Dolphin Individuals^
NMFS 1999&	1999	Summer							2	7	1	250
NMFS 2002&	2002	Spring										
Hansen et al. 1994	1992	Winter					1	6				
Sum			**105**	**240**	**7**	**7**	**2**	**8**	**5**	**11**	**1**	**250**
Mean Group Size			***2.3***		***1.0***		***4.0***		***2.2***		***250.0***	

Source	Year of Survey(s)	Season	Killer Whale Groups^	Killer Whale Individuals^	Melon-headed Whale Groups^	Melon-headed Whale Individuals^	False Killer Whale Groups[X]	False Killer Whale Individuals[X]	Spinner Dolphin Groups[X]	Spinner Dolphin Individuals[X]	White-sided Dolphin Groups*	White-sided Dolphin Individuals*
AMAPPS 2010	2010	Summer								10	185	249
AMAPPS 2011	2011	Winter								27		
AMAPPS 2011	2011	Summer									16	234
AMAPPS 2012	2012	Fall									8	278
AMAPPS 2012	2012	Spring									20	208

Source	**Year of Survey(s)**	**Season**	**Killer Whale Groups^**	**Killer Whale Individuals^**	**Melon-headed Whale Groups^**	**Melon-headed Whale Individuals^**	**False Killer Whale Groups^X**	**False Killer Whale Individuals^X**	**Spinner Dolphin Groups^X**	**Spinner Dolphin Individuals^X**	**White-sided Dolphin Groups***	**White-sided Dolphin Individuals***
AMAPPS 2013	2013	Winter										
AMAPPS 2013	2013	Summer										
AMAPPS 2014	2014	Spring	1	4			1	13			17	131
CETAP 1982	1978-1981	Year-round	12	85			1	7	4	170	584	31276
NMFS 1993&	1993	Summer										
NMFS 1996&	1996	Summer										
NMFS 1999&	1999	Summer			1	20						
NMFS 2002&	2002	Spring										
Hansen et al. 1994	1992	Winter			1	80						
Sum			**13**	**89**	**2**	**100**	**2**	**20**	**4**	**170**	**682**	**32561**
Mean Group Size			***6.8***		***50.0***		***10.0***		***42.5***		***47.7***	

**The sightings of blue and bottlenose whales were all north of the proposed seismic survey area. Harbor porpoise were all north of the proposed survey area with the exception of 8 groups seen during AMAPPS surveys in winter 2013 in nearshore waters between Delaware and North Carolina, and 2 groups totaling 3 individuals seen during AMAPPS during spring 2014 in nearshore waters of New Jersey/Delaware. Sightings of sei whales were all north of the proposed seismic study area with the exception of 2 probable sightings during CETAP (1982): 1 off the coast of Delaware/Maryland and 1 off the coast of North Carolina. Pygmy killer whales observed during CETAP were north of the proposed seismic study area, but pygmy killer whales observed in 1992 (Hansen et al. 1994) were seen off the coast of North Carolina. White-sided dolphins seen during CETAP (1982) were all north of the proposed seismic survey area with the exception of 3 sightings off the coast of Delaware/Maryland. White-sided dolphins were not seen in the proposed seismic survey area during AMAPPS surveys with the exception of 1 sighting between 37 and 38°N in 2013 for which no group size was reported.

[X] AMAPPS (2011) reports that false killer whales and spinner dolphins were each observed once but the number of individuals is not reported. There is no NOAA Stock Assessment Report for false killer whales in the Western Atlantic. One group of false killer whales was seen off the North Carolina coast during AMAPPS 2014 and 1 group was also seen off North Carolina during CETAP. (1982). Two of the 4 groups of spinner dolphins observed during CETAP (1982) were north of the proposed seismic study area

[^] One group of killer whales was seen off the Virginia coast during AMAPPS 2014; 8 of the 12 sightings during CETAP (1982) were north of the proposed seismic study area. One group of Fraser's dolphins was seen off the North Carolina coast during NMFS surveys in 1999; 2 groups of melon-headed whales have been observed off the North Carolina coast in NMFS surveys (1999 & 2002).

[&] NMFS 1993, 1996, 1999, and 2002 reports were not directly available for reference; the information from these reports is provided here based on the SAR for each species (Waring et al. 2014). This information was used because no or very little other information was available on several species.